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The Capitalocene Part II: accumulation by appropriation and the centrality of unpaid work/energy

Jason W. Moore

This essay – Part II – reconceptualizes the past five centuries as the Capitalocene, the ‘age of capital’. The essay advances two interconnected arguments. First, the exploitation of labor-power depends on a more expansive process: the appropriation of unpaid work/energy delivered by ‘women, nature, and colonies’ (Mies). Second, accumulation by appropriation turns on the capacity of state–capital–science complexes to make nature legible. If the substance of abstract social labor is time, the substance of abstract social nature is space. While managerial procedures within commodity production aim to maximize productivity per quantum of labor-time, the geo-managerial capacities of states and empires identify and seek to maximize unpaid work/energy per ‘unit’ of abstract nature. Historically, successive state–capital–science complexes co-produce Cheap Natures that are located, or reproduce themselves, largely outside the cash nexus. Geo-managerialism’s preliminary forms emerged rapidly during the rise of capitalism. Its chief historical expressions comprise those processes through which capitalists and state-machineries map, identify, quantify and otherwise make natures legible to capital. A radical politics of sustainability must recognize – and seek to mobilize through – a tripartite division of work under capitalism: labor-power, unpaid human work and the work of nature as a whole.

Keywords: world-ecology; history of capitalism; Anthropocene; political ecology; historical political economy; environmental history; historical geography

The Anthropocene has become the most important – and also the most dangerous – environmental concept of our times. That danger is not immediately obvious, and for a good reason: the Anthropocene has sounded the alarm of planetary crisis. It has rendered a signal contribution to our understanding of that crisis, clarifying ongoing ‘state shifts’ in planetary natures (Barnosky et al. 2012). As biospheric analyses proliferated, so too the urgency to identify the ‘prime movers’ behind these planetary shifts. On this, the Anthropocene does not clarify. It mystifies. It obscures. It falsifies.

No phrase crystallizes this danger more than this one: *anthropogenic global warming*. Of course this is a colossal falsification. Global warming is not the accomplishment of an abstract humanity, the *Anthropos*. Global warming is capital’s crowning achievement. Global warming is *capitalogenic* (Street 2016).

The Anthropocene’s popularity derives from something more than impressive research. Its influence has been won on the strength of its capacity to unify humans and the earth system within a singular narrative. There is little question that a unified narrative is urgently

needed. *How* it unifies the earth system and humanity within a singular narrative is precisely its weakness, and the source of its falsifying power. For the unification is not dialectical; it is the unity of the cyberneticist – a unity of fragments, an idealist unity that severs the constitutive historical relations that have brought the planet to its present age of extinction.

In the three years since my initial sketch of the Capitalocene (Moore 2013a, 2013b, 2013c), the concept has gone viral.¹ For me, the Capitalocene is partly a play on words. It is a *geopoetics* (Last 2015), a counterpoint to the Anthropocene's extraordinary popularity. It is a means of cutting to the heart of the conversation initiated by Crutzen and Stoermer (2000). That conversation, as we saw in Part I (Moore *in press*), has been twofold. One is an argument about stratigraphy. In this, the necessary criterion for designating a new geological era turns on a 'geological signal' that 'must be sufficiently large, clear and distinctive' on a global scale (Working Group 2016). This is the Geological Anthropocene. It begins, we are now told, at the mid-century dawn of the atomic age (Carrington 2016).

The Geological Anthropocene – a useful, 'formal concept to the scientific community' – has, however, been eclipsed by the Popular Anthropocene: a way of thinking the origins and evolution of modern ecological crisis. This is a debate joined by the Capitalocene – and the stakes are anything but silly (contra Chakrabarty 2016). The Popular Anthropocene poses several daunting questions: (1) What is the character of twenty-first century ecological crisis?; (2) When did that crisis originate?; and (3) What forces drive that crisis? That conversation, except briefly in the 1970s (e.g., Meadows et al. 1972), was marginal until the new millennium.

Crutzen and Stoermer's Anthropocene enjoyed the virtue of all Big Ideas – timing. It helped that the Anthropocene is a quasi-empty signifier. Like globalization in the 1990s, it could be filled with the aspirations and arguments of otherwise radically divergent thinkers (compare Steffen et al. 2007; Davis 2010). Quasi-empty, however, is not completely vacant. The Popular Anthropocene has worked not only because it is plastic, but because it fits comfortably with a view of population, environment and history governed by food and resource use – and abstracted from class and empire (and not only class and empire).

If that sounds neo-Malthusian, it is. Not for its emphasis on population, but for ignoring modernity's 'special laws of population' (Marx 1967, I: 592) – human and non-human alike (e.g., Seccombe 1992; Weis 2013). In Anthropocenic thought, history is the first casualty; like Malthus in the eighteenth century, its major exponents substitute an abstract time for history, evacuating the very historical perspective that might give explanatory flesh and blood to their quantitative reckonings. Among Malthus's greatest errors was his inability to situate the late eighteenth century's quite real combination of agricultural stagnation and population increase within longer waves of agricultural revolution and demographic change (see Seccombe 1992, 1995; Moore 2010d).

The Capitalocene is therefore precisely *not* an argument about geological history (contra, e.g., Vansintjan 2015). For starters, the 'Age of Capital' necessarily precedes and precipitates the 'geological signals' necessary to discern a new geological era. That era – the Anthropocene – will outlast capitalism by a great many millennia. The biospheric conditions of the ongoing planetary 'state shift' will shape the conditions of human organization for a very *longue durée* indeed.

¹I chart the genealogy of the Capitalocene elsewhere (Moore 2016b). The term originates with Andreas Malm. The *conceptual* use of the Capitalocene to signify capitalism as a system of power, capital and nature is broadly shared with Haraway (2016). Haraway and I began experimenting with the concept independently before discovering each other in 2013.

The Capitalocene *is* an argument about thinking ecological crisis. It is a conversation about geo-history rather than geological history – although of course the two are related. As we encountered in Part I, the Capitalocene challenges the Popular Anthropocene’s Two Century model of modernity – a model that has been the lodestar of Green Thought since the 1970s. The origins of modern ecological crisis – and therefore of capitalism – cannot be reduced to England, to the long nineteenth century, to coal or to the steam engine. The Anthropocene’s historical myopia, moreover, seems to be immanent to its intellectual culture. In this respect, the Capitalocene challenges not just the earth system scientists – but also those on the ‘other’ side of the Two Cultures (e.g., Pálsson et al. 2013; Brondizio et al. 2016; McNeill and Engelke 2016) – *who refuse to name the system*. The Popular Anthropocene is but the latest of a long series of environmental concepts that deny the multi-species violence and inequality of capitalism and assert that the devastation created by capital is the responsibility of all humans. The politics of the Anthropocene – an *anti-politics* in Ferguson’s sense (1990) – is resolutely committed to the erasure of capitalism and the capitalogenesis of planetary crisis.

The Anthropocene helpfully poses the question of Nature/Society dualism, but cannot resolve that dualism in favor of a new synthesis. That synthesis, in my view, rests on rethinking capitalism in the web of life. While it is now commonplace to invoke – quite properly – ‘system change, not climate change’, we should take care with how we think that system. A critique of capitalism that accepts its self-definition – as a market or social system abstracted from the web of life – is unlikely to guide us toward sustainability and liberation. We should therefore be wary of views of capitalism reduced to ‘human exceptionalism’ (Haraway 2008). Exceptionalisms are always dangerous. This is especially so when it comes to Humanity, a real abstraction active in a long history of racialized, gendered and colonial violence (see Part I; Moore *forthcoming*, 2016b). The world-ecology conversation has argued the opposite: capitalism develops through the web of life. In this movement, human *sociality* has been brutally reshaped through Nature/Society as real abstractions, enabling modernity’s successive racialized, gendered and class orders (von Werlhof 1988; Plumwood 1993; Moore 2015a).² This double-layered question of nature – as Nature/Society and as web of life – is implicated in every moment and movement of modern history.

Human organizations cannot, therefore, be reduced to the mythical domain of Society: a concept whose arbitrary boundaries obscure the constitutive geobiological relations of human sociality. In this light, human organizations are at once producers and products of the web of life, understood in its evolving mosaic of diversity. From this perspective, capitalism becomes something more-than-human. It becomes a world-ecology of power, capital and nature (Moore 2003a, 2011, 2015a, 2016a; Weis 2013; Bolthouse 2014; Camba 2015; Cox 2015; Deckard 2015; Dixon 2015; El Khoury 2015; Kolia *forthcoming*; Taylor 2015; Altvater 2016; Gill 2016a, 2016b; Hartley 2016; Otero and Lapegna 2016; McBrien 2016; Niblett 2013; Campbell and Niblett 2016; Oloff 2016; Parenti 2016; Ortiz 2016; Jakes *forthcoming*; Walker and Moore *forthcoming*; Marley *forthcoming*). This incorporates geological history but does not substitute for it. World-ecology refuses naturalism and constructivism – not in favor a balance between the two but in pursuit of their transcendence. It incorporates geobiophysical processes *and* social and economic history within a relational field. That wider field is crucial. It allows world-ecology to situate the

²Real abstractions ‘are not mental categories that ideally precede the concrete totality; they are real abstractions that are truly caught up in the [socio-ecological] whole’ (Toscano 2008, 274–75).

histories of culture and knowledge production within the history of capitalism (Moore 2015a, 193–217; Hartley 2016). The Capitalocene therefore contests social as well as environmental reductionism, and resists any periodization of capitalism derived from the mythic category of Society (humans without nature) (e.g., Angus 2016).³

Finally, the Capitalocene embodies world-ecology's rejection of two frames that dominate environmental social science. On the one hand, it seeks an alternative to concept-indicator approaches characterized by influential metaphors such as the 'ecological footprint' and the 'metabolic rift'. Such approaches conceptualize human organization – respectively, markets and capitalism – independently of the web of life, then mobilize indicators of the 'degree-of or amount-of' stress or degradation (Hopkins 1982, 201; e.g., Wackernagel et al. 2002; Foster et al. 2010). A relational approach, in contrast, follows part-whole movements in successive determinations and juxtapositions – through which the 'whole' in question (capitalism, imperialism, industrialization, etc.) undergoes qualitative transformation (Moore *forthcoming*). This logic of inquiry opens analytical pathways that emphasize capitalism's extraordinary flexibility through its socio-ecological conditions. The Capitalocene argument consequently treads a different path from the governing procedures of global environmental change research: it is not a quest for 'underlying [social] causes' of environmental change, nor for connecting 'social organization' to environmental consequences (respectively, Dalby 2015; Brondizio et al. 2016).

On the other hand, in arguing that climate change, for instance, is capitalogenic, world-ecology argues *against* the view that climate change is Sociogenic. That may seem a fine point. It is anything but. The conflation of human sociality with Society is a conceptual move indebted to a long history of gendered, racialized and colonial violence (see Part I). The Capitalocene pursues a different approach, privileging a triple helix of environment-making: the mutually constitutive transformation of ideas, environments and organization, co-producing the relations of production and reproduction (Merchant 1989; Worster 1990; Seccombe 1992; Moore 2015a). Here is an alternative to the vulgar materialism of too many global environmental change studies, for which ideas, culture and even scientific revolutions have little traction.⁴ Even that, however, does not go nearly far enough:

The challenge for us may then be to use descriptive tools that do not give to Capitalocene the power to explain away the entanglement of earthly, resilient matters of concern, while adding that no Capitalocene story, starting with the 'long sixteenth century', can go very far without being entangled with the on-going invention-production-appropriation-exploitation of ... 'cheap nature'. In other words, we should not indulge in the very Capitalocene gesture of appropriation, of giving to an abstraction the power to define as 'cheap' – an inexhaustible resource that may be dismembered or debunked at will and reduced to illusory beliefs – whatever escapes its grasp. (Stengers 2015, 142; see also Moore 2015a, 2016a, 2016c; Haraway 2016)

The Capitalocene, then, is a key conceptual and methodological move in rethinking capitalism as 'a historically situated complex of metabolisms and assemblages' (Haraway et al. 2016, 21). This complex includes – but cannot be reduced to – capital's circuit of expanded reproduction. The concept's virtue, in relation to alternatives, is its

³Although this is how Malm (2016) uses it.

⁴A problem besetting radical as well as mainstream accounts (e.g., Foster et al. 2010; Steffen et al. 2011).

historical-relational focus. Alternative naming has proliferated – a hopeful and positive indicator of flourishing discontent with the Popular Anthropocene. The equally ungainly terms offered as complementary, even alternative, to Anthropocene/Capitalocene frequently reveal innovative thinking. Some orient toward Braudel’s ‘very *longue durée*’ (2009, e.g., Pyne’s Pyrocene [2015]); others to modernity’s forms of production (e.g., Tsing’s Plantationocene [2015]); still others to violent abstractions created by the past century’s colonial developmentalism (e.g., Growthocene, Econocene [Norgaard 2013; Chertkovskaya and Paulsson 2016]). The objection that the Capitalocene elides the experience of Communist projects is framed by a concept-indicator epistemology – a surprising critique when offered by otherwise relational thinkers (e.g., Morton 2016). But the Capitalocene is a dialectical – not generalizing – claim. In contrast to positivist generalization, dialectical arguments proceed *through*, not in spite of, variation. The Capitalocene names a historical process in Marx’s sense of the tendency of the rate of profit to fall (1981): as a general law constituted *through* counter-acting tendencies. To what degree either the Soviet or Chinese projects represented a fundamental break with previous waves of capitalist environment-making is an important question but beside the point. The question is whether or not such partial moments overwhelmed the ‘developing tendencies of history’ reproduced through the *longue durée* of the capitalist world-ecology (Lukács 1971, 181).⁵

In Part I we explored the history of capitalism’s environment-making through the double register of real abstractions (Nature/Society) and land/labor transformation. Part II charts a different course. In what follows, I explore how capitalism values – and de-values – life and land. If capital is value in motion, if the substance of value is socially necessary labor-time, and if value is how capital recognizes wealth, it becomes crucial to grasp how value works in the web of life. This is among our best guides to understanding *how* the limits to capital-in-nature (and nature-in-capital) will manifest in coming decades, and therefore an important guide to political action.

Dualism, dialectics and the problem of value

Cheap Nature is at the core of capitalism’s audacious and peculiar combination of productivism and exterminism. This too works on a double register. One is Cheap Nature as economic process. In this, Cheap Natures comprise those necessary elements of capitalist re/production – above all, labor, food, energy and raw materials. Cheap Nature accumulation strategies effect a rising *ecological surplus* when three changes occur simultaneously: (1) the value composition of the Big Four inputs declines; (2) biophysical throughput rises; (3) systemwide re/production costs fall (Moore 2015a, 91–167). This process naturally

⁵It is difficult for me to read the Soviet project as a fundamental rupture. The great industrialization drive of the 1930s relied – *massively* – on the importation of fixed capital, which by 1931 constituted 90 percent of Soviet imports. The Soviets were so desperate to obtain hard currency that ‘the state was prepared to export anything and everything, from gold, oil and furs to the pictures in the Hermitage Museum’ (Kagarlitsky 2007, 272–73). If the Soviet project resembles another of production, it is surely the tributary, not socialist, mode, through which the state directly extracts the surplus. Nor did the Soviets turn inward after 1945. Soviet trade with Organization for Economic Cooperation and Development countries (in constant dollars) increased 8.9 percent annually between 1950 and 1970, rising to 17.9 percent a year in the following decade (calculated from Gaidar 2007, 14) – a trend accompanied by sharply deteriorating terms of trade and rising debt across the Soviet-led zone (Kagarlitsky 2007). Need we recall that the 1980s debt crisis was detonated not by Mexico but by Poland in 1981 (Green 1983)?

unfolds through all manner of class and boundary struggles, binding Cheap Nature's 'economic', class and ethico-political moments. The latter works through Nature/Society dualism as a foundational real abstraction in the re/production of gendered and racialized domination. (Thus, movements against such domination have often stressed 'human' and 'civil' rights, underscoring the historical exclusions of women and peoples of color from Humanity and Society.)⁶ In this movement, Cheap Nature embodies a logic of *cheapening* in an ethico-political sense, relocating many – at times the majority of – humans into Nature, the better to render their work unpaid, devalued, invisibilized. Early primitive accumulation's epochal achievement went far beyond the expulsion of the direct producers from the land. It turned equally on the expulsion of women, indigenous peoples, Africans and many others from Humanity (Moore 2016b, forthcoming).

If nature *includes* humans, if humans are a 'natural force' (Marx 1973, 612), if human thought is embodied in an 'unbroken circle of being, knowing, and doing' (Maturana and Varela 1987, 25), if ideas themselves may constitute 'material forces' (Marx 1978, 60), we are presented with a challenge and an opportunity. Both turn on a historical method that moves from humanity *and* nature toward a double internality: humanity-in-nature and nature-in-humanity. From this standpoint, the critique of Nature/Society dualism can be linked to its transcendence. The alienated unification of fragments represented by Nature/Society – and Green Arithmetic (Nature plus Society) – can be effectively displaced. The alternative is a value-relational ontology. The paid work of (some) humans remains the economic pivot of capital – socially necessary labor-time. But its necessary conditions of reproduction are found in the *unpaid* work of 'women, nature, and colonies' (Mies 1986, 77). Capitalism thrives when islands of commodity production and exchange can appropriate oceans of potentially Cheap Natures – outside the circuit of capital but essential to its operation.

This entails a reconstruction of capitalism's value-relations to encompass exploitation (surplus value) within more expansive movements of appropriation: the extra-economic mobilization of unpaid work/energy in service to capital accumulation. In this approach, unpaid work comprises work, energy and life reproduced largely outside the cash nexus, yet indispensable to capital accumulation. I speak of work/energy rather than simply work because we are dealing with work in a broadly biophysical sense, comprising the activity and potential energy of rivers and soils, of oil and coal deposits, of human-centered production and reproduction (e.g., White 1995; Moore 2015a).

My reading of value-relations – co-produced through human and extra-human work – follows Marx's conception of abstract social labor as the substance of value. That common recognition, however, is insufficient. While Marxist political economy has taken value to be an *economic* phenomenon with systemic implications, I wish to ask whether – and how – the inverse formulation may be equally plausible: Can we not say that value-relations are a *systemic* phenomenon with a pivotal economic moment? The accumulation of abstract social labor is possible only to the degree that unpaid work (human and extra-human) can be appropriated: by forces and relations that are not themselves economic. Is this not already suggested by the long history of 'political exchange' between the owners of capital and the purveyors of imperial violence, from Genoa and Castile in 1492 to the Washington Consensus (Arrighi 1994)?

The value-form (the commodity) and its substance (abstract social labor) depend upon relations that configure wage-labor with its necessarily more expansive conditions of

⁶A point made brilliantly by von Werlhof (1988).

reproduction: unpaid work. Capital's appropriation of unpaid work transcends the Cartesian divide, encompassing both human and extra-human work outside, but necessary to, the circuit of capital. This implies something hugely important for Marxist thought, but with significance well beyond Marxism: the value-form and value relations are non-identical. The simplification, rationalization and homogenization of socio-ecological life that occurs through manifold commodity regimes – from the assembly line to agro-monocultures – works through a simultaneous process of exploitation (of paid labor) and appropriation (of unpaid work).

My thesis can be stated bluntly: The condition of some work being valued is that most work is not. My inspiration is the extraordinary Marxist feminist tradition (Dalla Costa and James 1972; Vogel 1983; Federici 2012; also Waring 1988). Only now, I think, is the potential of this critique becoming apparent. This points toward a conception of value-relations as co-produced through exploitation (capital-labor) and appropriation (capital-unpaid work). Cheap Natures form through the relations of paid and unpaid work, and the knowledge-practices necessary to identify and to appropriate it. Unifying the historical entanglements of human and extra-human activity – work inside and outside the circuit of capital – may well prove useful in developing effective analytics and emancipatory politics as modernity unravels today.

Nature, geopower and capitalogenic appropriation

Unifying these entanglements is tricky. In the capitalist era, these are not randomly distributed, but shaped by its dominant value system, operating simultaneously as 'economy' and as ethico-political rationality. This means, among other things, that capitalism's law of value is implicated in the construction of Nature/Society as analytical categories and real abstractions.

Like all civilizations, capitalism enacts and imposes a hierarchical valuation of reality – some things and some relations are more valued than others. Modernity's law of value, however, combines an unusually expansionary with an exceedingly narrow valuation of whose work counts – and whose does not. Feudalism's rules of reproduction turned on land productivity. That changed after 1450. Not all at once, to be sure. But noticeably, powerfully and steadily. The productivity of labor – not land – became the decisive metric of wealth.

Empires and capitalists registered this new metric in a repertoire of ingenious civilizational strategies. At their core was a logic of capitalist, territorial and epistemic power, focused on the appropriation of uncommodified work/energy. Those appropriations would – directly and indirectly – advance labor productivity within an exceedingly narrow sphere: the cash nexus. The new value-oriented *technics* – crystallizations of tools and ideas, power and nature – allowed the prodigious appropriation of uncommodified work/energy so as to advance labor productivity. The great leap forward in the scale, scope and speed of landscape and biological transformations in the three centuries after 1450 – stretching from Poland to Brazil, and the North Atlantic's cod fisheries to Southeast Asia's spice islands – may be understood in this light (see Part I).

This global landscape revolution revealed the power of capitalogenic appropriation: the mobilization of work/energy to advance the production of surplus value. As we shall see, imperialism was central to this story. But imperialism was not the whole story. It must be complemented by the ongoing revolutions in property and gender relations within Europe, through which agro-ecologies and women could be put to work cheaply (Brenner 1976; Federici 2004). The new law of value did not – *could not* – 'count' most productive work.

The rise of Cheap Nature and the rise of capitalism were inseparable. While feudalism powerfully reshaped Continental landscapes between the ninth and fourteenth centuries, the very terms of the lord–peasant relation moderated environmental devastation. Because the surplus derived from land rather than labor productivity, the rapid exhaustion of land threatened the reproduction of both peasant and seigneur. Mutual interdependency, coupled with modest capacities for geographical mobility, was embodied and reproduced through a view of nature that stressed ‘the whole before the parts’. It was, to be sure, an unequal whole – but as an ‘integrated system of nature and society’ (Merchant 1980, 70–72). That integrated system broke down quickly in the century after 1492.

Cheap Nature emerged out of the wreckage of feudal crisis. The ‘intellectual peace’ of lord and peasant yielded to intellectual war, detonated by entwined climatic, agro-ecological and class ferment of the early fourteenth century (Hilton 1973; Moore 2003b; quotation from Schumpeter 1942, 124). That cultural destabilization was progressively reinforced across the next two centuries, not least by the Black Death, escalating class struggles and intensified warfare.

By the end of the sixteenth century, a tipping point had been reached. The web of life was becoming Nature: a ‘new ethic sanctioning the exploitation of Nature’ (Merchant 1980, 164). Early capitalism’s world-praxis, fusing cultural and material transformation, advanced an audacious fetishization of nature. This was expressed, dramatically, in the era’s cartographic, scientific and quantifying revolutions. These were symbolic forms of primitive accumulation, creating a new mode of thought. Personified by Francis Bacon and Rene Descartes, that new mode presumed the separation of humans from the rest of nature, and the domination of the latter by the former. For early modern materialism, the point was not only to interpret the world but to control it: ‘to make ourselves as it were the masters and possessors of nature’ (Descartes 2006/1637, 51). If this sounds like a conqueror’s motto, it is. The Nature/Society binary is not only Cartesian but also after the brutal conqueror of Mexico, *Cortesian* (Gill 2016b).

Two epoch-making inventions occurred in this long sixteenth century. One was the invention of the New World (Mignolo 1995). This invention begins not with the invasion of the Americas but with the colonization and conquest of the Atlantic islands and completion of the Reconquista in the half-century before 1492. Here was a new form of conquest, premised on new ‘technologies of distance’ (Porter 1995, ix), beginning with the new cartography (portolan charts) and shipbuilding (caravels). The second was the invention of a progressively rationalized ‘cost-profit calculus’ (Schumpeter 1942, 123). Double-entry bookkeeping – like the mechanical clock – was invented in the late thirteenth century, becoming two centuries later an expressive moment of a calculative revolution that reshaped the world (Weber 1978; Gleeson-White 2012). If its directly causal role in the rise of capitalism is open to debate, double-entry bookkeeping – both as a practice and as a wider epistemic mode – was unquestionably important in this calculative revolution. Double-entry bookkeeping’s rapid diffusion from its north Italian hearth dates from – not coincidentally – the 1490s (Pacioli 1494/1984; Mills 1994). That diffusion carried the accounting system to the Andes after 1531, where it was among the key ‘elements of Spanish civil administration and ecclesiastical practice’ (Urton 2009, 802).

For Schumpeter, double entry’s diffusion after the 1490s marked a turning point in an evolving Western Rationality, increasingly captured by cost–profit calculus. Cost–profit accounting would thenceforth lead a ‘conqueror’s career’. It channeled Western Rationality into a profoundly economic rationality: ‘by crystallizing and defining numerically, it powerfully propel[led] the logic of enterprise’. Across a wider field, it proceeded by ‘subjugating – rationalizing – man’s tools and philosophies, his medical practice, his picture of

the cosmos, his outlook on life, everything in fact including his concepts of beauty and justice and his spiritual ambitions' (Schumpeter 1942, 123–24).

Geopower, geo-managerialism and accumulation by appropriation

This transition established capitalism's rules of reproduction. The Capitalocene has been premised on great bursts of labor productivity advance enabled by even greater bursts of appropriating Cheap Natures. For this reason, eras of agricultural and industrial revolutions are tightly connected to successive 'new' imperialisms. The logic is simple enough. Advancing labor productivity is rising material throughput for every unit of socially necessary labor-time. Rising throughput places demands on the place-specific re/production of labor, food, energy and raw materials. As throughput rises, so does the value composition of the Big Four inputs. Re/production costs rise, squeezing the rate of profit. Thence, the search for new Cheap Natures commences.⁷

This capital-logic model highlights the great weakness of capital. Capitalists are victims of their own success. To the extent that productivity advances in wide-ranging fashion, input costs rise, and one of two things must occur: boom turns to bust or new sources of supply are found. On a systemic level, however, new sources of supply are not easy to locate and put to work. Capitalists are not well equipped to map, code, survey, quantify and otherwise identify and facilitate *new* sources of Cheap Nature.

If capital is not well suited to do this, the modern state is. Thus, at the heart of modern capitalism is not only state and geopolitical power but *geopower*. Geopower emerges at the nexus of big science, big states and 'technologies of power that make territory and the biosphere accessible, legible, knowable, and utilizable' (Parenti 2016, 117). If geopower enforces Nature, it also renders Nature a motor of accumulation through the production of abstract social nature. This is *accumulation by appropriation*, the process of creating surplus profit via geopower and its production of abstract social nature.

If the substance of abstract social labor is time (socially necessary labor-time), the substance of abstract social nature is space. The two form a contradictory unity: the spatio-temporality of capitalism as a way of organizing nature. While managerial procedures within commodity production aim to maximize productivity per quantum of abstract labor, the geo-managerial capacities of states and empires pursue the identification and maximization of unpaid work/energy per unit of abstract nature. The managerial imperative to appropriate workers' knowledge in the production process – classically illustrated by Braverman's 'de-skilling thesis' – finds its world-historical complement in *geo-managerialism*: the 'separation of conception from execution' in capitalism's co-production of nature (1974, 79). Like labor process restructuring, geo-managerialism entails the restructuring of knowledge as a force of production. This allows us to incorporate intellectual labor into our thinking about the labor/land nexus of agrarian and planetary change. It has involved – as we shall see – a long history of bioprospecting, from Columbus to Monsanto. The enabling condition of these appropriations is the symbolic erasure of human work in caring and cultivating diverse natures (Gill 2016b).

Geo-managerialism is the specific form of geopower tasked with identifying natures' productive potential. Acting through geo-managerial principles, successive state-capital-

⁷Presented here as a logical sequence, the historical geography of this process is dynamic, overlapping and considerably messier (Moore 2015a).

science complexes produce ‘units’ of Nature that are located, or reproduce themselves, largely outside the cash nexus. Geo-managerialism’s preliminary forms emerged rapidly during the rise of capitalism, as real abstractions of time (linear), space (flat) and nature (external) emerged. Its chief historical expressions comprise those processes through which capitalists and state-machineries map, identify, quantify and otherwise make natures legible to capital. Just as the shop floor of bourgeois and proletarian manifests through a struggle over whose knowledge dominates, so the antagonism of capitalism in the web of life unfolds through a contest over whose geographical and geophysical knowledge dominates – obviously a central issue in the politics of food and climate justice today.

Geopower seeks ‘to capture and contain the forces of Nature by operationally deploying advanced technologies, and thereby linking many of Nature’s apparently intrinsic structures and processes to strategies of highly rationalized environmental management’ – and capital accumulation (Luke 1996, 2). In this light, the modern state re/produces the conditions of capital accumulation by making manifold natures – including human natures – directly useful to capital. These forms vary according to the mix of accumulation by capitalization and appropriation obtaining across the uneven time-space of the capitalist world-ecology. Every era of capitalism embodies not only dominant class structures and economic forms but also new regimes of geopower and geo-coding, through which dispossession and appropriation occur (Harris 2004).

The idea of Nature as external has worked so effectively – and for so long – for this reason. Effective power in the modern world pivots on the capacity to restore and maintain the conditions of capital accumulation (Arrighi 1994). These conditions are located outside the centers of commodification (commodity frontiers) or beyond the cash nexus (e.g., ‘women’s work’). Systemwide material expansions cannot resume without greatly expanded new flows, and new kinds, of Cheap Nature. Imperialism effects de-Humanization for this very reason: the better to cheaply extract the work and wealth of human and extra-human natures in new peripheries.

It is a cyclical and cumulative process. Because natures are historical and therefore finite, the exhaustion of one zone quickly prompts the ‘discovery’ of new natures that deliver untapped sources of unpaid work. Thus did the Kew Gardens of British hegemony yield to the American Century’s International Agricultural Research Centers, superseded in turn by the neoliberal era’s bioprospecting, rent-seeking and genomic mapping practices (Brockway 1978; Kloppenburg 1988; McAfee 1999; 2003).

Not only is capitalism bound up with a historically specific nature; so are its specific phases of development. Each long century of accumulation does not ‘tap’ an external nature that exists as a warehouse of resources. This does not mean new resources are conjured out of thin air. Resources *become* (Zimmerman 1951). Coal changed the world once the relations of class and capital activated its potential (Malm 2016). Each such long wave creates – and is created by – a historical nature that offers a new, specific set of constraints and opportunities. The accumulation strategies that work at the beginning of a cycle – creating particular historical natures through science, technology, and new forms of territoriality and governance (abstract social nature) – progressively exhaust the relations of reproduction that supply the Four Cheaps. (An exhaustion that includes class struggle.) At some point, this exhaustion registers in rising commodity prices and faltering profitability.

Joining the appropriation of Cheap Natures to the exploitation of commodified labor-power allows us to unravel some of the mysteries of early capitalism. A civilization with few significant resource or technological advantages, it nevertheless developed epoch-making capacities to reshape life and landscapes worldwide. One fruitful point of entry into this discussion is Marx’s argument that use- and exchange-value represent ‘*on the*

surface’ the ‘internal opposition of use-value and value’ (Marx 1977, 153, 209, emphasis added). This internal opposition contrasts with eco-Marxism’s tendency to deploy use- and exchange-value absent the value relations that form and re-form socially necessary labor-time (e.g., Foster et al. 2010; see Moore forthcoming). Marx’s opening discussion in *Capital* is pitched at so high a level of abstraction that I think the explosive implications of this ‘internal opposition’ have been missed. To say that value and use-value are *internally related* is to say that the value relation extends far beyond the point of production. Such a connection allows us to join definite ‘modes of production’ and definite ‘modes of life’ in concrete historical unities (Marx and Engels 1998, 42).

Unpaid work/energy and the accumulation of capital

Joining ‘life’ and ‘production’ points to a theory of capitalism centered on shifting configurations of exploitation and appropriation. That dialectic of paid and unpaid work demands a disproportionate expansion of the latter (appropriation) in relation to the former (exploitation). This reality is suggested by the widely cited estimates on unpaid work performed by humans (UNDP 1995, 16; Safri and Graham 2010) and the rest of nature (‘ecosystem services’) (Costanza et al. 1997, 2014). Quantitative reckonings of unpaid human work – overwhelmingly delivered by women – vary between 70 and 80 percent of world gross domestic product (GDP); for ‘ecosystem services’, between 70 and 250 percent of GDP. The relations between the two are rarely grasped, their role in long waves of accumulation rarely discussed (but see O’Hara 1995; Perkins 2007; Caffentzis 2013). I would observe that unpaid work comprises not only the active and ongoing contributions to the daily reproduction of labor-power and the production cycles of agriculture and forestry. Unpaid work also encompasses the appropriation of *accumulated* unpaid work in the form of children raised to adulthood largely outside the commodity system (e.g., in peasant agriculture) and subsequently pushed or pulled into wage-work, and also in the form of fossil fuels produced through the Earth’s biogeological processes.

The appropriation of unpaid work signifies something beyond the important notion of environmental costs and externalities as ‘missing’. Here we may work with feminist Marxism’s powerful insight that unpaid work is not ‘just there’, but actively produced through complex, patterned relations of power, re/production and accumulation. So too with the unpaid work of extra-human natures. The language of ‘free gift’ – Engels’ phrase, not Marx’s – is doubly misleading: these working natures were neither free nor gifted, but rather forcibly extracted by empire, science and capital. Cheap Natures are Cheap because the human and extra-human work that makes them possible is erased and devalued. Such forgetting feeds into a view of nature as passive substrate, a place where humans leave footprints (e.g., Wackernagel and Rees 1996).

Footprint metaphors mislead because they disregard the creativity of extra-human natures. They ignore how extra-human natures are also producers of historical change. Nature cannot be reduced to mere substrate or surface. I find it difficult to accept any concept that reduces the web of life to a substrate. This is how capital views nature. Its project seeks to reduce nature to mathematical abstraction. Life in the capitalist era rebels against these reductions and simplifications. Weeds evolve. Horses refuse to work. Viruses mutate. Extra-human natures, in other words, actively refuse their designation as Nature.

As a web of life, nature is the dynamic field within which life unfolds. That life actively, creatively, incessantly engages environment-making (Levins and Lewontin 1985; Moore 2015a, 51–74). This implies something hugely important for modern world history.

Human ingenuity (such as it is) and human activity (such as it has been) must *activate* the work of particular natures in order to appropriate particular streams of unpaid work. Such activation – the work of science, power and capital – is a co-produced reality, bundling the life-activities of human and extra-human nature.

What are the implications for a historically grounded theory of value? On the one hand, capitalism lives and dies on the expanded reproduction of capital: value-in-motion. The substance of value is socially necessary labor time. On the other hand, this logic values some activities and de-values others. That devaluation is not oversight. Cheapening human and extra-human work in an ethico-political sense – via Nature/Society as real abstractions – reduces the value composition of production and advances the rate of profit. Only work performed under the sign of capital counts. Other work – *most work* – necessary to capitalist development does not register as valuable. Moreover, cheapening suppresses sustainable reproduction. Most work, in other words, *does not count*. But it is still appropriated by capital – indeed, the unpaid work of human and extra-human natures is the decisive (but not sufficient) condition of capital accumulation. Because the law of value works as cultural system too – as a system of oppression, degrading and invisibilizing most work necessary to life – it justifies poverty, suppressing sustainable reproduction (Secombe 1995). That suppression tends to exhaust the work-capacities of manifold natures – either because they are degraded (‘wiped out’) or because they can no longer issue a rising stream of work demanded by the law of value’s insatiable demands (‘maxed out’) (Moore 2015a, 221–40).

Situating appropriation internal to value relations helps us think through a thorny problem posed by domestic labor debate (Vogel 1983). Instead of asking if the reproduction of labor-power directly produces value, we might instead ask how the reproduction of labor-power – largely unpaid – is *necessary* to capital accumulation. Unpaid work is the necessary condition for value as abstract labor. The two moments are ontologically unified, but uneven, non-identical and asymmetrical. The value *form* and the value *relation* are, in other words, not coincident. The production of surplus value and the reproduction of value relations cut across the paid/unpaid work boundary. Generalized commodification is sustained only through the revolutionizing of the productive forces simultaneous to the relations of *reproduction*. Hence, every era of capitalist development depends not only on new capital-labor regimes, but also on new gendered, racialized and scientific regimes of unpaid work.

The historical condition for socially necessary labor-time is socially necessary unpaid work. Labor-time is only partly determined through the circuit of capital. We must take care to make a part-whole distinction here. Labor-time forms *also* through the relations of power and knowledge that identify and channel unpaid work to flow into the determination of necessary labor-time; this is the translation of work into value. If abstract social labor names the capital-labor relation through which surplus value is produced, abstract social nature names the relation of capital-unpaid ‘worker’ through which the conditions of rising labor productivity are reproduced on an ever-expanding scale.

De-valued (unpaid) work is an ‘immanent ... antithesis’ within the generalization of commodity production and exchange (Marx 1977, 209). It is a contradiction between the expanded reproduction of capital and the simple reproduction of life. This tension – in successive turns enabling and constraining – necessitates frontier-making immanent to capital’s laws of motion. Not for nothing, Marx’s *Capital* and studies that follow in the mode of immanent critique often conclude on precisely this question of capital’s frontiers (e.g., Luxemburg 1913/2003; Harvey 1982). Long before Polanyi, Marx highlighted capital’s self-consuming logic, crystallized in his discussion of the Working Day and the

entwined exhaustion of the worker and soil fertility under capitalist agriculture (1977, 340–416; see also Burkett 1999; Foster 2000; Moore 2015a). This self-consuming logic is compelled by productive as well as market competition; the pressure to squeeze the last drop of work from human and extra-human natures is incessant. (A reality ably illustrated by the ascendancy of finance capital and its ethos of shareholder value in the neoliberal era.) The reserve army of labor can be treated as ‘cheap’ and ‘disposable human material’ because ‘physically uncorrupted’ workers can be found on the frontiers – overwhelmingly in colonial zones (Marx 1967, I, 443, 593; 1977, 380). Even if workers can be found cheaply, new productivity revolutions depend upon new and greatly expanded supplies of energy, food and raw materials. Without these latter, the costs of fixed and circulating capital tend to rise, throttling the rate of profit (Moore 2011).

Commodity frontiers have loomed so large in the history of capitalism for this reason. Frontiers as diverse as sugar planting, forestry and mining prefigured technological development in urban-industrial centers because these zones yielded extraordinary physical surpluses that could be transformed into capital. The commodity frontier strategy has been so important not because of the extension of commodity production and exchange as such – a common misunderstanding of commodity frontier theory (Moore 2000b, 2013d, 2013e). Rather, commodity frontiers were so epoch-making because they extended the zone of appropriation (of natures’ unpaid work) *faster* than the zone of commodification. Whenever appropriation slows relative to the mass of capital, the costs of production rise, the opportunities for investment contract, and a ‘new’ imperialism commences.

The law of value, far from reducible to abstract social labor, finds its necessary conditions of self-expansion through the creation and subsequent appropriation of Cheap Natures. If capital is to forestall the rising costs of production, the Big Four inputs must be secured through extra-economic procedures and processes. These include, but go well beyond, the cyclical phenomena of primitive accumulation (de Angelis 2007). Between the dialectic of ‘expanded reproduction’ and ‘accumulation by dispossession’ (Harvey 2003) are those practices committed to locating, quantifying and rationalizing human and extra-human natures. Thus, the trinity: abstract social labor, abstract social nature, primitive accumulation. This is the relational core of capitalist world-praxis. And the work of this unholy trinity? Produce Cheap Natures.⁸ Extend the field of appropriation. Deliver labor, food, energy and raw materials – the Four Cheaps – faster than the accumulating mass of surplus capital derived from the exploitation of labor-power. Why? Because the rate of exploitation of labor-power tends to exhaust the life-making capacities that sustain it (Marx 1977, 340–416; Wright 2006). Capital is indifferent to the Cartesian divide:

Capital asks no questions about the length of life of labor-power. What interests it is purely and simply the maximum of labour-power that can be set in motion in a working day. It attains this objective by shortening the life of labour-power, *in the same way* as a greedy farmer snatches more produce from the soil by robbing it of its fertility. (Marx 1977, 376, emphasis added)

This exhaustion might take the form of an obvious withering of ‘vital forces’ (Marx 1977, 380). More often, however, exhaustion manifests in the inability of a given production complex to yield a rising stream of unpaid work – performed by human and extra-human natures alike. This latter form of exhaustion typically issues from some combination

⁸*Produce* does not mean ‘call forth at will’, but rather a dialectic of co-production (Marx 1977, 283).

of class struggle, biophysical change, and the tendentially rising ‘geographical inertia’ of regional built environments (quotation from Harvey 1982, 428–29). In a world treated as boundless, capital as a whole has evinced a cumulative, but cyclically punctuated, tendency to search out and appropriate new, ‘physically uncorrupted’ zones (Marx 1977, 380). Exhaustion signals a rising value composition of capital, and the inflection point of decline for a given production complex to supply a growing stream of unpaid work to regional accumulation. To the degree that ‘foreign preserves’ can be identified and dominated, the relative ‘degeneration of the industrial population’ matters little (Cairnes 1862, 110–11 quoted in Marx 1977, 377, 380).⁹

Has it been so different for extra-human natures? English agriculture was relatively exhausted in terms of its capacity to send a rising stream of Cheap Food to metropolitan capital by the early nineteenth century. Not surprisingly, British capitalism at its mid-century apex would nourish itself on the basis of cheap calories – grain and sugar – supplied from frontiers in North America and the Caribbean (Cronon 1991; Mintz 1985; Moore 2015a, 241–90).

We can now connect the development of capitalism and the law of value. Value relations incorporate a double movement of exploitation and appropriation. Within the commodity system, the exploitation of labor-power reigns supreme. That supremacy depends, however, on the appropriation of uncommodified natures outpacing exploitation. This relation has been difficult to discern because value *relations* are necessarily broader, and less well defined, than the value *form* (the commodity). Commodity production expands through a web of value relations whose scope and scale extends considerably beyond production proper. Capitalist development in this sense occurs through the uneven globalization of wage-work *dialectically joined* to the ‘generalization of its conditions of reproduction’ (McMichael 1991, 343).

The dualisms immanent in modern thought discourage such connections. Analyses that transcend Nature/Society and cognate binaries of race and gender challenge a core structure of modernist thought (Plumwood 1993, 41–68). Not only do we need to unify the distinctive but mutually formative dialectics of human and extra-human work under capitalism through the nexus paid/unpaid work. We also need to recognize that capitalism’s dynamism relies on appropriating and co-producing ever more creative configurations of work/energy across the *longue durée*.

Once the nexus paid/unpaid work comes into focus, value relations cannot be reduced to a relation between the owners of capital and the possessors of labor-power. Bourgeois and proletarian remain a central expression of capital’s contradictory essence. Paid and unpaid work is another, constitutively implicated and frequently decisive, contradiction. The pedestal of socially necessary labor-time is socially necessary unpaid work. Labor-time forms

⁹Movements to drive down labor costs are found in technical innovation in core industrial sectors, alongside class politics and imperial initiatives to widen the sphere of appropriation. Thus, English labor-to-capital costs were 60 percent higher than on the Continent in the mid-eighteenth century, encouraging mechanization (Allen 2011, 31–32). Nevertheless, the new industrialization gathered steam in those regions of England – such as the northern Midlands – where wages were low relative to southern England (Hunt 1986). Yet, such mechanization was possible, especially after the 1780s, because of technical innovations that were ‘capital-saving’ as much as they were ‘labor-saving’ (von Tunzelman 1981), at least until the 1830s (Deane 1973). In textiles, we are clearly dealing with rising labor productivity. But even here the technical composition of capital (the mass of machinery) could rise much faster than its value composition because of opportunities for appropriating cheap energy and cheap iron through the coal/steampower/iron nexus.

not only through capital-labor conflict but also through the provision of unpaid work – a profoundly gendered, racialized and multi-species conflict (Hribal 2003; Federici 2004; Gill 2016b). This contradictory unity works by creating a relatively narrow sphere of commodity production within which labor-power yields either rising or falling productivity. This narrow sphere, the exploitation of labor-power, sails in oceans of appropriated work/energy. Here, the diversity of nature’s work – including the reproduction of life from the family to the biosphere – may be taken up into commodity production, but not fully capitalized.

After 1492 this law of value, turning on socially necessary labor-time, formed within an expansive (*and expanding*) domain of appropriation. Early capitalism excelled at this: developing technologies and knowledges unusually well suited to identifying, coding and rationalizing Nature. (Alongside highly militarized trade.) Here the new way of seeing the world – inaugurated by Renaissance perspective – decisively conditioned a new organizing *technics*, manifested in the cartographic-shipbuilding revolution of early modernity, from Portolan maps and caravels to Mercator globes and galleons. Although widely characterized as pre-industrial, the ‘soft’ technics of geopower – producing abstract social natures – underwrote successive waves of industrialization long before the nineteenth century. Mining, metallurgy and sugar planting are only the most conspicuous examples (Mumford 1934; Mintz 1985; Moore 2007).

Appropriating Cheap Natures is a productive activity. Its importance is as great as exploitation. The outright seizure of basic wealth – clearly no invention of the sixteenth century – provided no durable basis for the endless accumulation of capital. That basis was co-produced through the concatenation of appropriative strategies, reliant on and pushing forward a world market itself forged through empire-building, scientific revolutions and technological innovation. These strategies comprised quite conscious colonial strategies to reorganize indigenous populations into strategic hamlets that functioned as labor reserves: the *reducciones* in the Andes and the *aldeias* in Brazil (Schwartz 1978; Gade and Escobar 1982). In the Spanish zone, these hamlets assumed a highly rationalized form, organized according to ‘grid-like ground plans to [facilitate the] ... surveillance, control and indoctrination’ (Urton 2012, 27). Such practices enabled a rising rate of exploitation by seeking to check – not advance – proletarianized reproduction. The reproduction of life in the *reducciones* offered non-commodified means of subsistence, reducing the value of labor-power of those entrained in Spanish labor draft, the *mita* (Moore 2010e). Horrific mortality mattered little, so long as the costs of appropriation – through indigenous and African slave trades – were sufficiently low (Schwartz 1985; Moore 2007).

The conventional reading of Marx offers two categories of surplus value: absolute (more hours worked) and relative (more commodities produced per hour). Marx focused on the basic tendencies in the rise of large-scale industry. Clearly, rising labor productivity owed much to the era’s rising technical composition of capital. Marx’s emphasis was not, however, a rule for all time. Machinery is not the only productive force. Relative surplus value can also be enabled by appropriated unpaid work/energy: soil fertility may ‘act like an increase of fixed capital’ (Marx 1973, 748). We can take this reference to soil fertility as a shorthand for the life-making capacities of human and extra-human natures. Does it not also apply to the real abstraction ‘women’s work’?¹⁰ Even where extraordinary soil fertility was in some sense ‘given’, it was equally co-produced: the fertility of seventeenth-century Bahia or the nineteenth-century American Midwest and Great Plains (Cronon 1991; Moore 2007). Absent the long sixteenth century’s cartographic-shipbuilding revolution, or the railroad revolution and the rationalization of American territory in the long

nineteenth century, the bounty of these frontiers was no more than *potential*. These ‘hard’ and ‘soft’ technologies of production advanced labor productivity by harnessing the capacities of these natures to work for capital – and for free. It took work to get these natures to work for free, and this was the genius of early capitalist technical advance. Sugar and wheat frontiers remade the world only through extraordinary movements of capital, knowledge and work, each movement a mighty expenditure of energy aimed at transforming nature’s *work* into the bourgeoisie’s *capital*. Yes, coal and oil are dramatic examples of this appropriation of unpaid work. This observation – that fossil fuels have been central to great leaps forward in labor productivity – is turned into a fetish when the same reasoning is not applied to early capitalism. The ‘fossil capitalism’ thesis falters only when it refuses to see capitalism as ontologically and historically multi-layered, containing the contradictions of not one, but many, eras of capitalism (see Part I).

The relation between value, work and nature in early capitalism has been engaged either in mercantilist frames (emphasizing technological inertia) or in frequently insightful, but much too partial, economic histories (e.g., respectively Wolf 1982; de Vries 1976). I have argued that early capitalism offered its own revolution in labor productivity, largely disguised because it relied so heavily on accumulation by appropriation. In Part I, we saw how this productivity revolution involved widespread mechanization – in milling, sugar processing, shipbuilding, mining and metallurgy, printing, even textiles. Our usual ways of measuring such productivity surges are, however, inadequate, because they are unable to integrate unpaid work/energy. The challenge is to identify how configurations of paid and unpaid work stabilize, and are cyclically restructured, through successive accumulation regimes. Labor productivity, in other words, takes not one but many forms. For early capitalism, we might ask: How do we internalize, analytically, the fertility windfalls of *massapé* soils in seventeenth-century Brazil? Of the unpaid work of the families of the *mitayos* (forced wage-workers) traveling to the Potosí mines, and of African families whose children were enslaved? Of Norwegian and Baltic forests that supplied the shipbuilding centers of the Dutch Republic? Of peasant cultivation to the off-season iron-making work of Swedish peasants, whose labor costs were correspondingly much lower than those of their English competitors? One might be tempted to say that these are merely natural ‘windfalls’ (Webb 1964) – a variation of the low-hanging fruit thesis. But was this not equally true of coal and oil in the ‘first’ and ‘second’ Industrial Revolutions?

Early capitalism’s productivity revolution turned not only on Smithian specialization, technological change and organizational innovation, but also on the capacity of European empires and colonial production to appropriate soil fertility and other work. The contrast with European natures was considerable. In English agriculture around 1800, the average ‘worker-hour’ yielded about 2600 calories (Clark 2007, 67–68). In contrast, the average ‘worker-hour’ in swidden agriculture in early nineteenth-century Brazil, cultivating manioc, maize and sweet potatoes, yielded anywhere between 7000 and 17,600 calories (Clark 2007, 67–68; see also Werner et al. 1979). This windfall ratio – on the order of 1:5 between established and frontier zones – is suggestive of early modern labor productivity advance. Indeed, that ratio may explain something of the spectacular increase in trans-Atlantic shipping – by tonnage – in the sixteenth century (de Vries 2010, 720).

¹⁰Here, Federici’s critique of Marx is correct to the letter (2012) – that Marx does not recognize the centrality of reproductive work. It also obscures the methodological possibilities of connecting the appropriation of unpaid work to relative surplus value.

If this rough-and-ready estimate is plausible (Moore 2007), we are looking at a revolutionary expansion of early modern labor productivity, one rivaling the Industrial Revolution.

This tells us that a key reason behind the consolidation of early capitalism was its ability to appropriate the astounding potentialities of uncommodified natures. If sixteenth-century Europe was exceptional in any technological sense, it was this. Food works well as an example, because the metrics are easy, but one could multiply the appropriations of worker-hour windfalls to all sectors of early capitalism. How would worker-hour productivity in timber vary between, say, coppiced English forests and the relatively unmanaged Norwegian forests of the late sixteenth century? Or between long-exploited Central European silver mines and Potosí's Cerro Rico around 1550? In a narrow sense, these differences were not 'produced' in any straightforward, linear, sense. But neither were these bountiful frontiers just there for the taking. *They were co-produced.*

Serendipity and strategy entwined in early capitalism's productivity revolution: serendipity insofar as New World crops such as maize, potatoes and manioc were high yielding; strategy insofar as the new commodity frontiers (sugar and silver above all) actively constructed their re/production complexes around such high-yielding crops. Even where Old World crops were introduced – the Spaniards in colonial Peru loved wheat bread – the initial yields were extraordinarily high (an order of magnitude greater than the Europe average) and remained so for the first long wave of colonial domination (c. 1545–1640) (Super 1988; Moore 2010e). The point can scarcely be overstated: Cheap Nature, as civilizational strategy, 'acts like an increase in fixed capital'.

The catch? The cheapening of food – along with raw materials and energy – cannot be accomplished by economic means alone. Cheap Nature could be realized only through regimes of abstract social nature. These encompassed the 'primitive accumulation of botanical knowledge' organized by Iberian botanical gardens (Cañizares-Esguerra 2004, 2006), a new 'map consciousness' (Pickles 2004), and the 'death of nature' inaugurated by early modern materialism (Merchant 1980).

Historical capitalism has been able to resolve its recurrent crises because territorialist and capitalist agencies have extended the zone of appropriation faster than the zone of exploitation. This has allowed capitalism to overcome seemingly insuperable 'natural limits' through coercive- and knowledge-intensive appropriations of global nature, producing the Four Cheaps: labor power, food, energy and raw materials (Moore 2015a). Significant enlargements in the zone of appropriation resolve capitalism's crises by effecting a remarkable – and necessarily short-lived – trick: they mobilize unpaid work/energy without directly paying for its reproduction. The externalities of appropriation work only insofar as they are kept external – 'off the books'. Modernity is in this sense a mighty 'code and control' project, driving the widest range of quantifying and categorizing procedures: identifying, securing and regulating human and extra-human natures in the service of accumulation. This latter is the terrain of abstract social nature.

Historical natures: value, world-praxis and abstract social nature

Geopower produces abstract social nature through a repertoire of strategies comprising law, property and surveying, mapping, indeed the 'whole system of surveillance, hierarchies, inspections, bookkeeping, and reports ... that can be described as the disciplinary technolog[ies] of labor' (Foucault 2003, 242, 2007, 16–39; also Scott 1998, 2–3). If the hallmarks of abstract social labor are control and exploitation, the defining characteristics of abstract social nature are control and *appropriation*. We are looking at simplification, measurement and mapping as mechanisms of capitalist domination, and its ambition to bring ever-wider

‘domains of experience under systematic’ control (Wise 1995, 5). These expansive (and expansionary) processes of ordering and rationalizing domains of experience clearly cut across the Cartesian binary, seeking to identify and enclose any form of life-activity – including the congealed work of extremely ancient life – that might be useful for capital accumulation.

‘Science, capital, and power’: historical capitalism, historical natures

The unity of ‘science, capital, and power’ has long been suggested by critical agrarian scholars (Brockway 1979, 461; also Kloppenburg 1988; Patel 2012). I am not sure, however, that this unity has been sufficiently linked to the history of capital accumulation, and the value-relations at its core. Grounding science, capital and power in the web of life requires – as the Geological Anthropocene rightly contends – a periodization of ‘natural’ history in which human activity matters. To accomplish such a co-productive view of history, however, one must historicize not only human activity, but the natures that encompass it.

The dialectic of abstract nature and abstract labor is at the heart of those historical natures that are cause, consequence and unfolding condition of world accumulation. This entails a shift: from seeing nature as *resource* to seeing nature as matrix, as *historical nature*. Does this mean we no longer need to talk about resources? Hardly! It does, however, mean that we recognize the bourgeois representation of nature – of resources as things-in-themselves – as both a fetish and a project to create a specifically modern Nature. To move beyond the fetish, we may view resources as bundles of relations rather than geo-biological properties *as such* – without of course denying these properties. The journey from geology to geohistory necessitates a historical method that grasps the material-symbolic formation of power in human organization. Thus a world-ecological view of, say, coal’s ‘agency’ since 1800 allows us to distinguish the geology of coal from coal’s geohistory – to discern geological from historical facts. Geohistorically speaking, whomever says capital in the era of large-scale industry implicates coal. Those who say fossil fuels make industrial capitalism are not wrong so much as errant in the insertion of a non-relational object (coal) in the relational process of capital accumulation (e.g., Malm 2016). As Roberts aptly puts it:

too many histories of ‘resource commodities’ cast the identities of the substances they analyze in a teleological way – viewing them as ‘always already’ defined in terms of the dominant way we have come to use them. Take the example of coal, which is virtually always defined by historians as a fossil fuel... This conflates this use-oriented identity of coal with the coal’s claimed ‘essence’. But just as there is no such thing as ‘human nature’ (pace Marx), I would argue that what we take to be the ‘nature’ of individual materials is also a product of history. To ignore this is to ignore or underplay the role of human choice (*in collaboration with qualitatively distinct materials, of course*) in shaping environmental history. (L. Roberts, personal communication. 24 September 2016)

By itself, coal is only *potential*. Bundled with the relations of class, empire and appropriation in the nineteenth century, however, coal becomes something quite different. It becomes a way of naming a ‘mass commodity’ – a ‘marker for [an] entire historical epoch’ (Retort 2005, 39) – whose hand was in every strategic relation of nineteenth-century capitalism. Resources, then, are actively co-produced; they are markers and creators of the historical natures that help to define the scope of opportunity and constraint in successive eras of capitalist development. If this sensibility has long been registered theoretically (Harvey 1974),

the historiography of resource extraction has seldom taken the relational point seriously (e.g., Bunker and Ciccantell 2005; Wrigley 2010).

What ‘counts’ as a resource changes along with the *oikeios* – the relational, creative, and multi-layered relation of life-making (Moore 2015a, 33–49). To paraphrase Marx, coal is coal. Only under specific conditions does it become fossil fuel, and come to shape entire historical epochs. My name for these specific conditions is *historical* nature. Historical nature is not an output of capitalism. Capitalism does not produce an external ‘historical’ nature according to its needs (a functionalist position). Nor does capitalism simply respond to external changes in nature (a determinist position). Rather, phases of capitalist development are at once cause and consequence of fundamental reorganizations of world-ecology (Moore 2000a, 124). Both ‘capital’ and ‘nature’ *acquire new historical properties* through these reorganizations: hence the couplet historical capitalism/historical nature may be given real *historical* content. Historical natures are, in other words, a dance of the dialectic between part (modes of humanity) and whole (the web of life) through which particular limits and opportunities come to the fore (Ollman 2003).

Historical nature is a question of how the layers of historical time – even geological time – shape each other (Braudel 1972–73). This is suggested by the close relation between climate and the rise and demise of great civilizations – say Rome over the Roman Climatic Optimum or feudal Europe during the Medieval Warm Period (Crumley 1994; Lieberman 2009). In this alternative, cascading movements of the web of life enter into particular historical-geographical configurations of power and production. If human sociality articulates these relations – in its double meaning (to connect and to give expression to) – the biosphere is its integument. In contrast to the widely held view of nature as ‘nature in general’, a more illuminating vantage point is offered by seeing *historical* natures as co-produced. They are specific part–whole combinations – civilizations-in-nature – in which specific ‘geological, hydrographical, climatic, and [biogeographical]’ conditions enter into the most intimate, and also the most expansive, domains of human history (Marx and Engels 1998, 37).

Capital, labor and power move *through*, not around, nature; they are ‘specifically harnessed natural force[s]’ (Marx 1973, 612). Capital is itself co-produced. In turn, it co-produces specific historical natures, albeit under conditions that are full of resistances and frictions to capital’s desire for a world of fungible, passive and malleable life.

Abstract social nature results from that impulse toward radical simplification. It forms through geopower and its ‘rationality of world domination’ (Altvater 2016).¹¹ There is, to be sure, meaningful overlap and mutual constitution between the mapping and quantifying practices associated with abstract nature and those of abstract labor. At this point, I can pose but not resolve the homologous movements of standardization and simplification within commodity production and across the zones of socio-ecological reproduction. Preliminarily, something like Frederick Winslow Taylor’s famous time-and-motion studies (1914) – the basis for the scientific management revolution of the early twentieth century – belong to the zone of abstract social labor, reworking already-commodified relations (Braverman 1974). On the other hand, something like the imposition of the metric system in Revolutionary France belongs to the zone of abstract social nature, representing

¹¹The Weberian tradition has long made the argument for the centrality of modernity’s forms and logics of rationalization. In my view, the differences with Marx’s value-relational approach have been overstated, unproductively framed by economy/culture and economy/polity dualisms. The argument for abstract social nature incorporates certain elements of the Weberian – and Foucauldian – traditions, but with an eye to those practices that directly enter into the identification and appropriation of sources of unpaid work in service to capital accumulation.

a fundamental advance of capitalist rationality into weakly commodified domains (Kula 1986; Alder 1995). The distinction is porous. The ‘hard’ transformations of material life, represented by abstract social labor in the commodification process, are complemented by the ‘soft’ process of symbolic practice and knowledge formation. (Primitive accumulation is the necessary cyclical mediation between the two.) These ‘soft’ techniques – always with the brute force of states and empires behind them – aim to discover new sources of unpaid work/energy; the goal is to secure access to minimally or non-commodified natures (the Four Cheaps) for as close to free as possible.

Value as project and process

In the English language, value signifies two big things. First, it refers to those objects and relations that are *valuable*. Second, it refers to notions of morality, as in the fact/value binary that has loomed so large in modernist thought. Marx’s deployment of the ‘law of value’ is precisely aimed at identifying the relational core of capitalism, grounded in the expanded reproduction of abstract social labor. Marxists ever since Marx have defended the law of value as an economic process that encompasses that first meaning of value, naming those relations that capitalist civilization deems *valuable*. And so it has been difficult indeed to argue that the operation of the law of value may encompass both meanings of value.

Difficult. But not impossible. Historically speaking, it is hard to deny that new knowledge practices – cartographies, botanical and agronomic science, modes of calculation from double-entry bookkeeping to Black-Scholes – have been fundamental to capitalist development. To introduce such symbolic-cultural affairs into value’s relational core destabilizes the subjective/objective binary presumed by most political economy. The ‘objective world’ of value has been forged through the subjectivities of ‘capital’s imagination’ (Haiven 2011). Value’s calculative character is therefore a matter of capital deploying its symbolic power to represent the arbitrary character of value relations as objective (Bourdieu 1979; Bourdieu and Wacquant 1992).

Knowledge/culture and value as abstract labor are closely linked. But how? Abstract social nature – legible units of unpaid work/energy – is produced systemically through processes aimed at simplifying, standardizing and otherwise mapping the world in service to the accumulation of wealth as abstract labor. In this reading, abstract social nature turns on the capital/unpaid work relation. It names the spatio-temporal practices that identify and facilitate the appropriation of unpaid work. These appropriations do more than supply necessary raw materials; in so doing they co-determine socially necessary labor-time. In this, abstract nature can be understood as directly constitutive of value *relations* in creating the conditions for the generalization of commodity production and exchange. This has never been a linear sequence – either with new knowledges in the lead, or as derivative of commodification. It is a conjunctural affair. Cascading processes of commodification, capital accumulation, and symbolic and scientific innovation constituted a virtuous – if contingent – circle of modern world development.

I agree with Marx: the substance of capital is abstract social labor. The relations that make abstract labor’s growth possible, however, cannot be reduced to technology and economics. They are also grounded in geopolitics’ *technics* and the conditions for the expanded reproduction of capital on a world scale. We may begin with the law of value’s drive to convert the ‘natural distinctness’ of particular commodities into ‘economic equivalence’ (Marx 1973, 141), and particular labor processes into ‘general types of work motions’ (Braverman 1974, 125). The tension between ‘natural distinctness’ and ‘economic

equivalence' may well include more than exhaustion and depletion, encompassing resistance and revolt by extra-human natures alongside humans. To be sure, we may be wary of a broad-brushed call for eco-centric equivalence, in which all forms of resistance are created equal. Clearly, they are not. Neither should we refrain from identifying a common thread: weeds confound the simplified landscapes of agro-factories; workers defy and creatively adapt around the simplification of work tasks. In these we find a common resistance to the capitalist project, seeking to reduce space and life to interchangeable parts.

That project seeks to create a world in the image of capital. It finds ideological expression in neo-classic economics – in which the elements of human and extra-human nature are effectively interchangeable. In the fantasy of neoclassical economics, one 'factor' (money, land, labor) can be substituted for another, and the elements of production can be moved easily and effortlessly across global space (Perelman 2007). This effort to create a world in the image of capital is capitalism's correspondence project, through which capital seeks to compel the rest of the world to correspond to the imaginary (but quite real) desire for a universe of 'economic equivalence'.

Of course the world does not want a world of economic equivalence. Life rebels against modernity's value/monoculture nexus, from farm to factory to finance. The struggle over the relation between humans and the rest of nature in the modern world-system is necessarily a class struggle. Attempts to think class struggles abstracted from their geo-biological moments will fatally undermine emancipatory projects. The struggle over the grip of commodification is, in the first instance, a contest between contending visions and values of life and work. Extra-human natures, too, resist the grim compulsions of economic equivalence (Hribal 2003; Moore 2012). In this, capitalism's correspondence *project* meets up with all manner of contentious visions and resistances to create a historical *process* full of contradictions.

Amongst these contradictions, we find those countervailing forces that threaten to slow capital's turnover time and to defy capital's radically simplifying disciplines. Working class struggle in the heartlands of industrial production is a good example (Montgomery 1979; Silver 2003). So too is the revolt of extra-human nature in modern agriculture, where a distinctive form of struggle manifests: the 'battle with weeds' (a plant in the wrong place) and troublesome pests (Clayton 2003). The pesticide/herbicide treadmill (and its cognates) is bound up with Cheap Nature strategies that hothouse evolutionary adaptation at the point of production and shape the condition of world accumulation. On the one hand, as the flurry of news reports on the 'superweeds' sweeping across the GMO soy zones of the USA revealed in 2010–2011, biological natures now appear to be evolving faster than the capacity of capital to control them – resulting in a 'Darwinian evolution in fast-forward' (Neuman and Pollack 2010). On the other hand, the revolt of extra-human natures is aided by the revolutionary biogeography of world accumulation. From 1492, 'the accumulation of capital ... is strongly and positively associated with the accumulation of alien invasive species' (e.g., Crosby 1972; Perrings 2010). The temporal speed-up and geographical rationalizations of the capitalist mode of production are counter-balanced by a tendency toward 'geographical inertia' (Harvey 1982, 428–29) which encompasses *all* environments entrained within value's gravitational pull. The very transformations that enabled the speed-up of capitalist history – including its hothousing of evolutionary process – are implicated in accumulating resistances that threaten an epochal reversal (Moore 2015b).

How have these spatio-temporal contradictions, of compressed time and simplified space, been resolved? By and large, through geographical expansion and restructuring.

Both turn on shifting costs and appropriating unpaid work – inward toward the relations of reproduction (e.g., the shift to the two-income household in the North since the 1970s), outward toward minimally commodified zones. The paired movements of geographical expansion and restructuring are at the core of capitalism’s successive spatial fixes, necessary to resolve successive *conjunctures* of overaccumulation. They are constituted, from the standpoint of value relations, through a double movement: (1) widening and deepening the zone of commodification (value production/abstract social labor); and (2) on an even greater scale, the widening and deepening the zone of appropriation.¹² This latter turns on the production of abstract social nature, produced through the biopolitical, geographical and scientific-technical knowledges necessary to secure and restore the Four Cheaps. New frontiers of *unpaid work* must be identified, and put to work for capital.

This reading of the law of value highlights the difference between capitalism as project and process. Capitalism, as project, creates the idea and even a certain reality of ‘the’ environment as an external object. Nature as external, as real abstraction rather than *oikeios* – the creative relation of species and environment-making – is not entirely false. It is, rather, amongst capitalism’s greatest achievements. Recognizing Nature as a real abstraction allows us to grasp the development of capitalism’s productive forces as simultaneously socio-cultural and socio-material, dialectically unified through geo-managerialism’s organizing of ‘mental’ and ‘manual’ labor. Just as labor history shows how the separation of mental and manual work was a major lever of productivity change in in the twentieth century (Edwards 1979), so the history of abstract social nature reveals a cognate separation at work in the making of Cheap Nature. While capitalist and territorial power always pursue radical simplification (value as project), those projects are continually upended, limited, and challenged by human and extra-human natures (value as process). This is the dialectic of project and process.

Abstract social nature and the rise of capitalism

By the sixteenth century, we find abstract social nature at the core of a nascent law of value mobilizing material and symbolic machineries of power and production. Bound up closely with changing material life was a new epistemology and ontology:

The new approach was simply this: reduce what you are trying to think about to the minimum required by its definition; visualize it on paper, or at least in your mind, be it the fluctuation of wool prices ... or the course of Mars through the heavens, and divide it ... into equal quanta. Then you can measure, that is, count the quanta. (Crosby 1997, 228)

Early capitalism’s epoch-making abstractions – constituting a vast but weak regime of abstract social nature – were registered through the era’s new cartographies, new temporalities, new forms of surveying and property-making, schools of painting and music, accounting practices and scientific revolutions (Landes 1983; Cosgrove 1985, 2008; Mumford 1934; P. Harvey 1993; Postone 1993; Crosby 1997; Pickles 2004; Warf 2008;

¹²Missed in Harvey’s pioneering formulation (1982) – and subsequent elaborations – is the significance of successive waves of producing built environments *across* the urban–rural divide. While the production of urban built environments facilitates the circulation of capital and the exploitation of commodified labor-power, the production of town-country and agrarian built environments *also* facilitates the productive appropriation of unpaid work for capital, enabling flows of the Four Cheaps to move from country to city. Brenner and Schmid’s groundbreaking arguments on planetary urbanization point in precisely this analytical direction (e.g., 2015).

Blomley 2014). This vast but weak regime matured toward the end of the sixteenth century. The dynamic center of abstract social nature would be – not surprisingly – the Low Countries and, after 1600, the Dutch Republic. Here space, time and money were rationalized and abstracted as never before. In the northern Netherlands after 1585, the era's leading mapmakers excelled in the number of maps produced and in their quality (Koeman et al. 1987; Unger 2011). So central was cartographic knowledge to the Dutch East India Company (Vereenigde Oost-Indische Compagnie) that pilots of VOC vessels were given uniform instructions to map new territories in minute detail. (This was a greatly elaborated procedure initiated in the previous century by Spain's *Casa de Contratación* [Mignolo 1995]). By 1619, the company had created an internal mapmaking office to coordinate flows of geographical knowledge (Zandvliet 1987). Nor were these mapping impulses strictly colonial. Internal to the northern Netherlands, polderization, water-control and capitalist agriculture propelled a cadastral revolution whose surveys were so detailed they would not be superseded for two centuries (Kain and Baigent 1992). Work-time, too, was subjected to a 'radical rationalization' after the 1574 synod of the Reformed Church, which 'abolished *all* holy days', extending the work-year 20 percent by 1650 (de Vries 1993, 60, 2008, 88–89, emphasis in original).

Money, too, was radically rationalized. Again, the VOC loomed large. Its 1602 formation gave new form to world money- and credit-creation dramatized with the foundation of the Amsterdam Bourse (stock market) the same year, and the Amsterdam Exchange Bank in 1609. As American silver flowed into Amsterdam it provided the conditions for the rise of fiat money (Quinn and Roberds 2007). World money is always *bundled*, 'always material as well as calculative' (Mitchell 2011, 111). World money is also a powerful lever of organizing world nature – and is vitally dependent upon such organizations. The American silver flowing into Amsterdam was produced by massive physical infrastructures, an extreme geographical reorganization of Andean life, and no small amount of colonial force (Moore 2010e). As for the Bourse, not only were shares of the Dutch East India Company traded, but also, very soon, a growing number of commodities (360 different commodities by 1639!) and even option-derivatives (futures). The Bourse's material coordinations and symbolic 'rationality provided the basis for a universalisation and intensification of world credit practices which served to set the Dutch[-led world] financial order apart from pre-modern world finance' (Langley 2002: 45; see also Petram 2011, 23–24 and passim; Arrighi 1994, 138–40; Dehing and 't Hart 1997, 53).

These early modern developments suggest giving a significant role to the world-historical configuration of 'mental' and 'manual' labor (Braverman 1974). One fruitful angle of vision on capitalist history turns on its successive scientific revolutions that actively co-produced distinctive historical natures in and through phases of world accumulation. These revolutions not only produced new conditions of opportunity for capital and states, but transformed our understanding of nature as a whole, and, perhaps most significantly, of the boundaries between humans and the rest of nature (Young 1985). The point has been underscored by neoliberalism's systematic combination of shock doctrines with revolutions in the earth system and life sciences, tightly linked in turn to new property regimes aiming to secure not only land but life for capital accumulation (Klein 2007; Cooper 2008; Mansfield 2009). This has unfolded at the global and molecular scales, and everywhere in between (McAfee 2003). On the one hand, the new life sciences emerging after 1973 (with the invention of recombinant DNA) became a powerful lever for producing new conditions of accumulation premised on redistribution and speculation – patenting life forms, starting with the micro-organisms recognized in 1980 by the US Supreme Court (Bowring 2003). The ambition has been to enclose 'the reproduction of life itself within the

promissory accumulation of the debt form' (Cooper 2008, 31). On the other hand, the earth system sciences, aided considerably by mapping technologies (e.g., remote sensing, geographic information systems, etc.), have sought to reduce

the Earth ... to little more than a vast standing reserve, serving as a ready resource supply center and/or accessible waste reception site ... [They] aspire to scan and appraise the most productive use of ... [the] resourcified flows of energy, information, and matter as well as the sinks, dumps, and wastelands for all the by-products that commercial products leave behind. (Luke 2009, 133; e.g., Costanza et al. 1997).

Such 'planetarian accountancy' (Luke 2009) implicates more than biophysical surveillance. It also encompasses the production of new financial techniques committed to the same worldview of 'scanning and appraising' the most profitable investment opportunities, what Lohmann calls *quantism* (2009; see also Altvater 1993).

Neoliberalism's fearsome assemblages of science, capital and power have a long history. Bioprospecting has deep roots in the colonializing thrust of early capitalism (Schiebinger 2004), an era in which botany was (then as now) not only 'big science' but 'big business' (Schiebinger and Swan 2005, 3; see also Smith and Findeln 2002). From the beginning, 'botany served the needs of transnational merchant capital' (Cañizares-Esguerra 2004, 99). Here is a key originary moment of abstract social nature. This was crucial at a time when much of the colonial project's profitability turned 'on natural historical exploration and the precise identification and effective cultivation of' extra-European plants (Naro 1999; Schiebinger and Swan 2005, 3). Such processes were in motion from the beginning. At the same time as the new sugar plantations were remaking Madeira (Moore 2009, 2010c), the Portuguese were also

developing a system of acclimatisation gardens and, long before the Dutch became dominant in this field, were carrying out a complex, although not highly organised, series of plant transfers, some of which were to have major economic consequences. In performing such transfers, the Portuguese built on much older patterns of distribution and pharmacological trade in the Indian Ocean region. The main contribution made by the Portuguese was to link such existing systems to the West African, Caribbean and Brazilian regions. The first agencies of plant transfers and the first founders of collecting and medicinal gardens under the Portuguese were the religious houses founded in the first years of settlement. (Grove 1995, 73–4; see also Cañizares-Esguerra 2004)

These movements indicate early capitalism's audacious appetite for Cheap Nature. That appetite was sated — always temporarily — by the new qualitative and expanded quantitative flows of work/energy enabled by the new abstractions. This explains some measure of the 'massive taxonomical exercise' that conditioned the rise of capitalism (Richards 2003, 19). And it's no coincidence that the taxonomical project revived vigorously in the 1740s, just as Europe entered a protracted agrarian depression (Abel 1980). That project was by this point embodied by Linnaeus:

When Linnaeus returned to Sweden [in 1738], he fulfilled numerous commissions for industrial and pharmaceutical uses of plants ... [,] and as superintendent of the botanical garden of the University of Uppsala devoted himself to raising seeds and cultivating plant transfers from colonial satellites. Like other botanists of the period, he explored the possibilities of plant cultivation in area[s] where cheap colonial labor was available, and studied economic plants to determine whether native-grown might substitute for imported. (Boime 1990, 475)

Like earlier Iberian and Dutch botanical initiatives, the Linnaean revolution was an imperial movement. While Linnaeus himself worked at a time when Sweden's colonial aspirations had given way to the pursuit of a 'self-sufficient state economy', his research relied heavily on the Swedish East India Company. His taxonomy was quickly taken up as a 'universal tool of colonialism' (Müller-Wille 2005, 35; Skott 2014). This botanical imperialism would be elaborated and extended: first by the Kew Gardens of the British Empire in the later nineteenth century, and then with Americans' International Agricultural Research Centers after World War II (Brockway 1978; Kloppenburg 1988; Drayton 2001). Each implied a new historical nature, shaped by the innovations of capitalist production, science and power in forging new and expanded opportunities for accumulation by appropriation.

The early modern materialist revolution that dethroned medieval holism and divine teleology was an important dimension of an epochal shift: from the historical nature of feudalism to the historical nature of capitalism (Foster 2000). Early capitalism's calculative and scientific revolutions replaced a mode of reason favorable to feudal arrangements with new mode, one of mathematical abstraction and cartographic perspective (Merchant 1980; Crosby 1997; Pickles 2004, 75–106). The project's audacity can hardly be overstated. Its novelty was not the employment of calculation and measurement – 'the ancients, too, already knew' (Heidegger 1997, 21) this – but in

asking ... how nature as such must be viewed and determined in advance, such that the facts of *nature* can become accessible to the observation of facts in general. How must nature be determined and be thought in advance, so that the entirety of this being [Nature] ... can become accessible to calculative knowledge ... ? The answer is that nature must be circumscribed as what it is in advance, in such a way as to be determinable and accessible to inquiry as a closed system of the locomotion of material bodies in time. What limits nature as such – motion, body, place, time – must be thought in such a way as to make a mathematical determinability possible. Nature must be *projected* in advance. (Heidegger 1997, 21–2, emphasis in original; see also Mumford 1934)

The new law of value manifested earliest, and most spectacularly, in two domains. The first could be found in a cascading series of landscape and bodily transformations across the Atlantic world and beyond (see Part I). The second was in developing thought-procedures that allowed European states and capitals to see time as linear, space as homogenous, and nature as external to human relations – all tightly bound to the 'objectification' of Nature (Heidegger 1997, 22–3). Capital's conceit, from its origins, was to re-present the world through the 'God trick' (Haraway 1988, 581): to treat the specifically capitalist ordering of the world as 'natural', claiming to mirror the world it was then remaking (Warf 2008, 40–77).

These remarkable innovations in ways of seeing and knowing were premised on a new quantism. Its motto? Reduce reality to what can be counted. Then 'count the quanta' (Crosby 1997, 228). This reductionism was paired closely with transforming space into something that could viewed from outside (the God trick). In this respect, Renaissance painting – linked tightly with the renaissance of Euclidean geometry in northern Italy¹³ – assumed an importance far beyond the aesthetic realm (Cosgrove 1985). Renaissance perspective 'turned the symbolic relation of objects into a visual relation: the visual in turn became a quantitative relation. In the new picture of the world, size meant not human or divine

¹³The critical advance came from the re-evaluation of Euclid and the elevation of geometry to the keystone of human knowledge, specifically its application to three-dimensional space representation through single-point perspective theory and technique' (Cosgrove 1985, 47).

importance, but distance' (Mumford 1934, 20). Such quantism robbed 'space ... of its substantive meaningfulness to become an ordered, uniform system of abstract linear coordinates' (Jay 1993, 52).

The new visual primacy was central to the evolution of modern property, knowledge and dis/possession in early capitalism. Early modern botanical illustrations were 'a central practice for investigating colonial nature and incorporating it into European science ... Seeing was intimately connected to both knowing and owning. Images of plants and animals were more than pleasant, secondary by-products of exploration: they were instruments of possession' (Bleichmar 2006, 82). Within Europe and across the Atlantic world, a different kind of image became pivotal to modern state-formation and property-making: the modern map, 'effectively an invention of the sixteenth century' (P. Harvey 1993, 8; see also Brotton 1997). The early modern transition in

mapping practices ... can be seen in terms of a series of concrete concerns about property and identity emerging from political economic [and world-ecological] transformations of the period. First, there was a need for maps to envision and consolidate new communities, increasingly imagined as territorially bounded states and discrete unities of people (articulated in terms of a common history, ethnicity or language and culture). Second, there was a need for plots and plans for estate planning as private property claims on land and capitalist practices of land alienation and sale increasingly became the norm. (Pickles 2004, 99)

This was the emergence of abstract social nature. Especially in relation to bourgeois property – as in seventeenth-century England – it is impossible to overstate this new of way seeing and mapping. The new survey practices served to 'reformat property' by reimagining such spaces as 'geometric' and 'calculable' (Blomley 2014; see also P. Harvey 1993). Landownership was, especially (but not only) in England, reduced to 'facts and figures, a conception which inevitably undermines the matrix of duties and responsibilities which had previously ... define[d] the manorial community' (McRae 1993, 341). This is the representational and calculative moment of the agrarian transition ably charted by Brenner (1976).

Mapping did not merely re-present space; it was a technology of conquest. Both global commodification and the global appropriation of unpaid work turned on *representing* the 'practical activities' of astronomical observation in a manner that was abstract, yet useful for capital and empires (Cosgrove 2008, 21). Mercator's great breakthrough (1569) was to construct

a plane representation which depicted the meridians as parallel to each other rather than, as is the case with the true representation of the globe, converging on the north and south poles. If this could be achieved, then it would be possible to chart across its surface a line of constant bearing that was straight, rather than a spiral as would be the case when trying to trace it on a globe. The importance of Mercator's innovation in terms of accurate navigational practice and commercial profit was quite clear. Instead of taking awkward and imprecise bearings on board ship across the surface of a globe or a portolan chart, his new projection allowed for a line of bearing to be drawn accurately across the surface of a plane map, explicitly foregrounding ... its usefulness to the art of navigation ... With pilots and navigators in mind, Mercator went on to outline the mathematical procedure which allowed him to employ an accurate grid of straight lines across his map, whilst also retaining the relative geographical accuracy of the topography of the globe. (Brotton 1997, 166)

Nor were the early modern origins of abstract social nature confined to space and extra-human nature. It was a small step to move from the calculative consideration of extra-

human natures, local property or global space, to considering human beings – slaves – in the same fashion. Indeed, the nineteenth-century calculative order in cotton would incorporate all these elements; Johnson 2013. Much as a meatpacker today demands a ‘standard hog’ from suppliers (Ufkes 1995), so the slave market of the seventeenth-century Caribbean demanded a standard slave: male, 30–35 years old, between five and six feet tall. This standard slave was a *pieza de India* (‘piece of the Indies’). Individuals who did not measure up were reduced to ‘pieces of Indies’ (Williams 1970, 139). While the *pieza de India* is often considered as a measurement for taxation (King 1942), it was in fact widely used in the seventeenth century as a unit of measuring labor-power, from Angola to the Caribbean (Emmer 1972, 736; Ferreira 2012, 27). The *pieza de India*

was a measure of potential labor [labor-power], *not of individuals*. For a slave to qualify as a *pieza*, he had to be a young adult male meeting certain specifications as to size, physical condition, and health. The very young, the old, and females were defined for commercial purposes as *fractional parts of a pieza de India*. *The measure was convenient for Spanish imperial economic planning, where the need was a given amount of labor power, not a given number of individuals*. (Curtin 1969, 22, emphases added)

The practices of abstract social nature reached a turning point on the eve of the Industrial Revolution (Kula 1986; Scott 1998). We are dealing with a dynamic interplay of the science and technologies of ‘court’ and ‘commerce’, going back to the fifteenth century (Misa 2004). Perhaps most dramatic was the generalization of the metric system after the French Revolution. Even here, the metrical revolution found its precondition in early capitalism’s new planetary consciousness (Pratt 1992; Grove 1995). The meter, defined as ‘one 10,000th part of the distance from the pole to the equator’, combined a global imagination with ‘extreme unworldliness’, far removed from realities of everyday life (Porter 1995, 26).¹⁴ Launched by French revolutionaries toward the end of the eighteenth century, the metric system ‘tended to follow the barrel of a gun, only becoming instituted in Germany in 1868, Austria in 1871, Russia in 1891, China in 1947, and of course never in the United States’ (Mirowski 2004, 150).

Why was the advance of the metric system so important? For many reasons, to be sure. But surely at the top of the list is the ‘story of how a rational language – the metric system – was deliberately crafted to break the hold of the Old Regime’s political economy and serve as the universal idiom of the modern mechanism of exchange’ (Alder 1995, 39). These ‘metrical revolutions’ (Kula 1986) were key moments of the agrarian class struggle. For peasant communities,

the subjective [and localized] form of measurement ... [was perfectly acceptable]. There were disagreements, but they could be negotiated face to face. Informal measurement was inseparable from the fabric of these relatively autonomous communities ... [In contrast,] the metric system was not designed for peasants. It did not bring back the true bushel [which varied by locality], but discarded the bushel in favor of a system of wholly unfamiliar quantities and names, most of them drawn from an alien dead language. The institutionalization of the metric system involved special difficulties because of the aspiration to universalism that helped to give it form. This universalism was consistent with the ideology of the revolution, and more particularly with the ideology of empire. (Porter 1995, 223, 26; see also McRae 1993)

¹⁴‘There is something radical in the metric system that is related to its revolutionary origin. The metric system was part of a larger project to introduce a rupture at all levels of collective life, to create a “new man”, to initiate a new era in history, and to rationalize social life as a whole’ (Vera 2008, 140).

So powerful was the quantifying drive in the nineteenth century that one wonders if it should not be christened the era of Quantification rather than Industrialization. Here again there was no fundamental rupture, but instead a qualitative reinvention and expanded redeployment of cost–profit calculus. In Johnson’s extraordinary account of cotton slavery, he lays bare the fundamental connections made between work, nature and world market through this new quantification:

The economic space of the cotton market was defined by a set of standard measures – hands, pounds, lashes, bales, grades – that translated aspects of the process of production and sale into one another. Those tools for measuring and enforcing quantity, quality, and value produced commercial fluidity over space, across time, and between modes of production *These measures served both as the imperatives by which the commercial standards of the wider economy might be translated into the disciplinary standards that prevailed on its bloody margin*, and as markers of the nonstandard, human, resistant character of the labor that produced the value that was ultimately being measured and extracted. *They marked both the extent to which the metrics of the exchange in Liverpool penetrated the labor practices of Louisiana and the extent to which the labor practices of Louisiana pushed outward to shape the practice of the global market.* (2013, 10, emphases added)

Such quantification cannot be separated from the history of racism. The rationalization of fragments represented by work, life and exchange worked through the reciprocating moments of abstract social nature and racism (Hartley 2016). For the slaveowners of the cotton South, such rationalization and the ‘*natural* order of the races . . . were not separable’. Their ‘racial ideology . . . was the intellectual conjugation of the daily practice of the plantations they were defending: human beings, animals and plants forcibly reduced to limited aspects of themselves, and then deployed in concert to further slaveholding dominion’ (Johnson 2013, 206–08, emphasis added).

These developments reveal something much different from facile representations of early capitalism as mercantile or ‘pre-industrial’ (e.g., Wolf 1982). The shift from land productivity to labor productivity revealed a new law of value. It crystallized through a double dialectic. The first was premised on exploitation: abstract social labor/capital and wage-labor; the second, on appropriation: abstract social nature/capital and unpaid work. Through capitalization, labor productivity advances with the rising value composition of production; through appropriation, labor productivity advances by seizing Cheap Natures, reducing the value composition of production and advancing the rate of profit. If profitability is to rise, appropriation must advance faster – geographically and demographically – than exploitation.

What I am suggesting is twofold. On the one hand, the systemic formation of value relations occurred through a cascading series of small and large shifts in the Atlantic world after 1450. These shifts transcended the convenient boundaries of economy, culture, politics and so forth; they favored a view of reality and a practice of material transformation that encouraged a mathematized, visualized and mechanical world-praxis. On the other hand, the emergence of a capitalist world-praxis depended upon the explosive growth of commodity production and exchange after 1450. That expansion was, nevertheless, quantitatively modest in the overall weight of the Atlantic world-ecology for some time, and insufficient *on its own* to effect the rise of capitalism. The genius of early capitalism – in contrast to medieval Europe – was its appropriation of Cheap Natures, such that the scale and speed of landscape transformations outpaced commodification as such (see Part I).

What we are looking at, after 1450, is a transition through which new rules of reproduction took shape, and new stakes of the game were established, creating new synergies of

power and re/production. That is the magic of great historical transitions. These new rules and stakes of the game turned on commodification, whose radical expansions after 1450 depended on the symbolic and material abstractions of concrete mental and manual labors. This was necessary for the transition from the appropriation of surplus-product to the accumulation of surplus-value.

Necessary, but not sufficient. That this transition involved more than abstract social labor has long been recognized. There is a considerable literature on primitive accumulation and the role of state power to secure the necessary conditions of capital accumulation (e.g., Perelman 2000; Harvey 2003; de Angelis 2007). No combination of state violence and capitalist innovation in commodity production could produce, however, the knowledges necessary to map, navigate, survey and calculate the world. This geopower remained limited. By calling this family of processes abstract social nature, we should not exaggerate. The Iberian pioneers excelled at cartography, natural history and navigation in ways clearly different from the mathematizing procedures of seventeenth-century science in northern Europe (Cañizares-Esguerra 2006). We should be under no illusions that this initial phase of producing new knowledges resembles the ideo-typical models of subsequent eras. By the same token, we underestimate at our peril the efficacy of Iberian global empire-building, made possible through the new technics of 'long-distance control' (Law 1986). These technics made possible durable trans-oceanic empires heretofore unknown in world history.

And for the value-added of calling the outputs of geopower 'abstract social nature'? Three reasons stand out. In the first instance, any conception of value as economically reductionist undermines our capacity to explain the rise of capitalism as a unity of power and re/production in the web of life. Second, historically speaking, it is difficult to sustain the *a priori* assertion of economic processes propelling the transition to capitalism. This simply inverts a Weberian emphasis on formal rationality. A framework that highlights the evolving configurations of European rationality, world conquest and commodification is better suited to explain the transition. The new 'measures of reality' – in accounting, time-keeping, mapping space and externalizing nature – were on an equal footing with mechanization. The cascading processes that facilitated – but did not ensure – the rise of capitalism had not one but several 'prime movers': mechanization, imperialism and state-formation, new modes of knowledge production, class struggles, and so forth. And so we are back to capitalism's world-historical trinity: abstract social labor, primitive accumulation, abstract social nature.

Finally, with geopower and abstract social nature we find a way out of state-centric readings, ably crystallized in Scott's (1998) arguments on 'state simplifications' and Foucault's wide-ranging discussions on governmentality and biopower (e.g., 2003, 2007). If states and empires produce social natures, they have also been embedded within the web of life and the logic of world accumulation. The state- and market-led simplifications identified by Scott (1998) and Worster (1990) reveal a range of processes aimed at simplifying, standardizing and geo-coding human and extra-human natures to facilitate capital accumulation. 'Nature, women and colonies', in this perspective, are not only plundered but *actively created* through symbolic praxis, political power, and capital accumulation. This active creation is signaled by the nexus: historical nature/abstract social nature/abstract social labor. This provides an interpretive frame for what we have seen in modern world history – worlds of landscapes, cultures, markets, states and production systems that resemble and reproduce (even as they contest or condition) the radical simplifications immanent in the value relation.

This reading of value allows us to explain what has been hidden in plain sight: the epoch-making transition in humanity's environment-making relations and patterns

beginning in the sixteenth century. These relations have today reached a limit because they can no longer secure or extract new streams of work/energy sufficient to revive accumulation. Civilizational limits are at once inside and outside; they are co-produced.

The foregoing outline of value relations sheds light on how these inside and outside moments interconnect historically, and in the present crisis. Value's logic encodes labor productivity as the decisive metric of wealth and mobilizes Nature to advance labor productivity. The logic of mobilization requires that Nature/Society work as real abstractions, so as to limit the domain within which labor productivity is measured. Most work/energy – including most humanly productive work – must be excluded from the cost–profit calculus in order for accumulation to work. The problem is that such exclusions must grow faster than the mass of accumulating capital. New frontiers must be appropriated, lest the problem of surplus capital intensify. That dynamic can never be reduced to an inside/outside model, for 'internal' domains of unpaid work are also progressively capitalized, not least because of ongoing 'boundary' struggles for justice (Fraser 2014).

Power, then, is at the center of every moment of value. In this, *geopower* assumes specific salience. Hence the organic whole of state, capital and science, committed to a triple imperative: to simplify natures, to advance the rate of exploitation, and to extend the domain of appropriation faster than the zone of exploitation. Marx's insight that soil fertility could 'act like an increase of fixed capital' was no throwaway comment. This observation speaks to capitalism's voracious appetite for non-capitalized natures, without which the labor productivity revolutions of the capitalist era are unthinkable. For every Amsterdam there is a Vistula Basin; for every Manchester, a Mississippi Delta.

From Anthropocene to Capitalocene

The alternative presented here does not deny that the Industrial Revolution was *a* turning point. Far from it! The Industrial Revolution *was* a turning point. But it was not the termination of a premodern developmental pattern (*contra*, e.g., Wolf 1982; Pomeranz 2000).

There was no fundamental rupture between 'early' and 'industrial' capitalism's logic of environment-making. While the *consequences* were unquestionably different, the relations of capitalization and appropriation were not. These relations were governed by a specifically modern law of value that gave primacy to labor productivity in the commodity sector. This value relation found its clearest expression in early capitalism's great commodity frontiers – in sugar, silver, copper, iron, forest products, fishing, even cereal agriculture (Moore 2000b, 2007, 2010a, 2010b). In the new frontier zones, cutting-edge technology combined with the rapid appropriation of non- or minimally commodified natures. By 1600, we find sugar mills in the canefields of Brazil, sawmills in thickly forested Norway, and a huge hydraulic-silver-mercury production complex in the Andes. In these regions we see capitalism's marriage of accumulation by capitalization (lots of machines) and accumulation by appropriation (lots of 'free gifts'): the savage coupling of productivity and plunder that conditions every great wave of accumulation.

This combination of technological precocity and appropriation also characterizes the key machine of the Industrial Revolution: the steam engine. England's coal mines sat atop carboniferous Americas, subterranean frontiers designed to extract the unpaid work of the 'first great wave of plant life to leave the oceans and colonize the land ... [their fossilized remains constituting] the highly concentrated vestige of extinct life' (Freese 2003, 3). Only here could the steam engine develop. Coal's cheapness at the mines made possible the Newcomen engine's 'economic success' after 1712. It was the only place where the engine's prodigious appetite for coal could be economically viable (Mokyr 1990, 84–85;

Freese 2003, 59–60). Nor was this dependency on Cheap Nature altered with the steam engine's diffusion into textile production. It was, Marx observes, 'only the large fall in the price of cotton which enabled the cotton industry to develop in the way that it did' (1971, 368). As American production soared, cotton prices plummeted, falling over 70 percent between 1785 and 1835 (Solar 2012). Not coincidentally, the 1830s also marked the transition from the watermill to the steam engine in English textiles (Malm 2016). Cotton became cheap for many reasons, but the unpaid work and racialized surpluses of the Mississippi Delta's fertile soils and African slaves loomed large – and was made possible in the first place through the extermination and expulsion of indigenous peoples. Far from breaking with early capitalist frontier-making, the Industrial Revolution amplified it.

The upshot? Before the Industrial Revolution, appropriate Natures and advance labor productivity. After the Industrial Revolution, appropriate Natures and advance labor productivity.

Can we deny coal's epochal significance? Who would want to? If our concern is the modern fossil fuel boom, then its origins can be found in the sixteenth, not the eighteenth, century (see Part I). That a new phase of capitalism was taking shape around Cheap coal by 1800 is not in question. But we ought to be careful about overstating its importance. France produced maybe 10 percent as much coal as England, and realized the same economic growth in the first three-quarters of the eighteenth century (Davis 1973, 301; see also O'Brien and Keyder 1978). The United States industrialized with some coal, but water and charcoal remained dominant until 1870 (Hobhouse 2005, 3–66).

What 'work' did all this coal perform for an emergent industrial capitalist order? Yes, rising labor productivity at the point of production was crucial. This was, however, only part of the story. Coal's *direct* contribution to advancing labor productivity remains unclear (Crafts 2004; Clark 2007). Accumulation by capitalization, as in Manchester's textile mills, relied upon the earth-shaking revolutions in accumulation by appropriation: the cotton/slavery nexus above all. By 1830, the new appropriations reached a critical threshold: the first major wave of railroad and steamship expansion occurred in 1831–1861, by which date 107,000 kilometers of railroad track had been laid and 803,000 tons of steamship were afloat (Hobsbawm 1975, 310). The tentacles of capital extended – in mere decades – into the hearths and hearts of uncommodified nature.

For the first time in human history, civilization on a planetary scale was possible. Thus were new conditions laid for two tightly connected developments. First, value relations became globally hegemonic. Second, even as the technical composition of capital rose, its value composition fell, enabled by the massive enlargement of the arena for accumulation by appropriation. These conditions, in concert with the productivity-advancing innovations of large-scale industry, set the stage for a new era of capital accumulation: one characterized by over- rather than under-production crises (Moore 2015a).

We might take the Anthropocene/Capitalocene debate as an opportunity to rethink the stale and static notion of the pre-industrial – still common in environmental studies. Early capitalism's food and resource constraints were nowhere near as inelastic as neo-Malthusian theory would have it, and nowhere close to their techno-biological limits (de Vries 2001). There *were* barriers, and these did emerge, in part, from landscape transformations. Soil fertility *does* run down, forests *are* cleared. To limit the story to such consequences, however, is not only neo-Cartesian but neo-Malthusian. A dialectical method moves us from environment as object (as real abstraction) to environment-*making*, a process of creating and transcending historical limits co-produced by humans and the rest of nature. Did coal come to the rescue because of a scarcity of power, or because of the balance of class power? Steam did not decisively vanquish water power in English textiles until the

1830s, partly because coal facilitated the concentration of production in cities with relatively tractable labor-power (Malm 2016). But coal did not resolve England's agro-ecological crisis. As English agriculture stagnated after 1760, grain was imported in growing volumes, at first from Ireland and then from North America. Steam did not, however, displace sails for most commodities – save cotton – until the 1850s, and then rapidly after 1870 (Harley 1988; Headrick 1988, 18–48; Sharp 2008; Jacks and Pendakur 2010). If the 1830s were a turning point in textiles, even as late as 1850 'preindustrial' innovations and practices held sway in transport.

Early capitalism's extraordinary material transformations and scientific-cultural revolutions fit uneasily with otherwise radically opposed neo-Malthusian and Marxist narratives. Are early modern transformations, material and symbolic, really footnotes to the 'real' story that begins in 1800? And is the story of humanity as 'geological agent' best narrated through the specter of neo-Malthusian resource scarcity and overpopulation? Or best told through the alleged subjectivity of humanity as unified agent in an era of the unprecedented global polarization of rich and poor?

Better, in my view, is to re-focus our attention on the relations of power and re/production that govern environment-making in the modern world-system. To focus on power, (re)production and nature necessarily highlights the long sixteenth century – rarely acknowledged in accounts of contemporary planetary crisis. This is no academic hair-splitting. Lacking a historical-relational perspective on how modernity develops *through* the web of life, the Popular Anthropocene is powerless to explain the early modern origins of the Geological Anthropocene. The relations of power, wealth and nature that emerged after 1450 made possible the long fossil boom of the past two centuries. The Popular Anthropocene registers an important reality. But *which* reality? McNeill tells us that 'coal transformed the world' (2008, 3). Is not the inverse more plausible?: *New relations of capital, science, and empire transformed coal*. Yes, the fossil boom transformed the *conditions* of capitalist civilization. Did these new conditions imply a fundamental rupture with early capitalism? This is the very line of questioning that the Popular Anthropocene rules out.

Capital, nature and work/energy in the twenty-first century

I have made three basic arguments in these two essays. First, the 'forces of production' cannot be reduced to machinery. They must include intellectual labor, especially the 'soft' technologies of surveying, mapping, and quantifying human and extra-human natures. It is not just the Anthropocene argument that assigns supernatural powers to technology. Green and Red politics have fallen into this trap as well: hence their common acceptance of the Industrial Revolution as *the* origin of capitalism and ecological crisis.

Second, both 'hard' and 'soft' technologies must be placed within the *technics* of capitalism. These *technics* comprised both technical forms (machinery, cartography, etc.) and cultural regimes: capitalism's cultural fixes unfold and enfold scientific revolutions and vice versa (Hartley 2016). Early capitalism's cultural revolutions produced successive racialized and gendered orders through the real abstractions of Nature and Society, effectively creating vast pools of Cheap human nature. In this category of Nature, we must recognize the gendered and racialized moments of primitive accumulation: the violent expulsion of most humans from Society. This was far more than discursive; it was deeply entwined with everyday life. The real abstractions of Nature/Society penetrated everyday life, reflected in new family forms, new forms of slavery (*modern* slavery), and the urbanization of rural life through the widespread use of European-style towns.

Third, the world-historical essence of advancing labor productivity – understood in surplus value terms – is the use of Nature’s unpaid work relative to labor-power. *Capitalist* technology works through a simple principle: advance the rate of surplus value. The rate of surplus value turns on many qualitative and quantitative factors and conditions. But since the basic feature of rising productivity is a rising quantum of energy and raw materials (circulating capital) per unit of socially necessary labor-time, the global rate of profit depends on a threefold process: (1) material throughput must go up within the circuit of capital; (2) the necessary labor time in the average commodity must go down; (3) the costs of circulating capital (which also affect fixed capital) must be reduced (if a boom is to occur) or prevented from increasing (if a crisis is to be averted). The rate of surplus value therefore bears a close relationship to accumulation by appropriation. Accumulation crises occur when capital’s demand for a rising stream of free – or low-cost – work cannot be met by human and extra-human natures.

Toward a radical politics of work/energy

Capitalism is, before all else, a specific mode of production committed to the endless accumulation of capital. And what is capital? Yes, value in motion, as every Marxist will tell you But the explanation must go deeper. Value is a specific crystallization of the ‘original sources of all wealth’: human and extra-human work (Marx 1977, 638). Marx emphasized that labor – and socialist politics – cannot be abstracted from nature:

Labour is not the source of all wealth. Nature is just as much the source of use values (and it is surely of such that material wealth consists!) as labour, *which itself is only the manifestation of a force of nature, human labour power.* (Marx 1970, 1, emphasis added)

Marxist and environmentalist thought – and their cognate political projects – have so often failed to find common ground because they have ascribed what Marx calls ‘supernatural powers’ (Marx 1970, 1) to one or the other side of the Nature/Society binary. A kind of labor fundamentalism and nature fundamentalism has prevailed. Politically, this manifests the absurd – and false – conflict between ‘jobs’ and ‘environment’. The tragedy of that false conflict once again surfaced in September 2016 around the projected completion of the Dakota Access Pipeline – a nearly 1200-mile pipeline to carry North Dakota crude oil to southern Illinois (Sammon 2016). The AFL-CIO (the country’s major labor federation) called on the federal government to ensure the pipeline’s completion (2016), even as the Standing Rock Sioux and their allies organized significant opposition (Queally 2016). This time, however, they also found support in the labor movement, not least from the National Nurses United, who declared the pipeline project a ‘continual threat to public health’ (2016). This convergence of labor and social movement politics around a broadly defined defense of socio-ecological reproduction suggests a development glimpsed by O’Connor a quarter-century ago (1998). As advanced capitalism extends the cash nexus into key domains of socio-ecological reproduction, not only does it threaten the wellbeing of human and extra-human natures, it also establishes new conditions of anti-capitalist struggle. These ‘new conditions’ turn on the relations of capitalism’s reproduction (health care, education, but also the planetary commons) and favor a radical politics of work and life that necessarily reaches beyond economism.

Whether or not Red and Green movements can find enough common ground in time to avert the worst of global warming is uncertain (Barca 2016). The stagnation of labor productivity growth since the 1970s may well intensify the jobs/environment conflict, even as

it reveals the practical bankruptcy of the capitalist growth model (Gordon 2012). Reading Marx will not magically resolve the conflict. But a radically ecologized and feminized reading of capitalism's history of exploitation and appropriation provides a way to talk about and think through work in ways that identify commonality – what I've called work/energy – without collapsing the distinctiveness of work practices and experiences. In this light, Marx may offer a way to cut through the mystifications of the Labor/Nature dichotomy – a dichotomy real enough in terms of capitalism's real abstractions but violently destructive of any socialist project aiming to emancipate not some, but all, life.

For work is always mobilized in and through the web of life. When we utter the phrase 'labor and nature', we should be clear, then, that we are speaking of a diverse and dialectical unity: labor-in-nature; nature-in-labor. The two are not separate – not in the sixteenth century's sugar plantations, silver mines, iron forges and shipyards; and not today, in the twenty-first century's sweatshops, call centers and fast food chains. Work is always work *in* nature, and human work is always work *with* nature. That work implies a triple transformation: of ourselves, of external nature, of our relations with other humans (Marx 1977, 283). And if the process is more complex for civilizations, these too must 'work'. What is civilization but a specific apparatus of mobilizing work – of humans, but also of plants, animals and geology?

Capitalism, however, could not survive a day without a third moment of work: the appropriation of *human* unpaid work, reproduced largely outside the cash nexus. Thus, a revolutionary politics of sustainability must recognize – and seek to mobilize through – a tripartite division of work under capitalism: labor-power, unpaid human work and the work of nature as a whole. This is the 'trialectic' of work in the capitalist world-ecology. For the question of the exploitation of labor-power presumes a more expansive apparatus not only of appropriating extra-human nature, but also for mobilizing the unpaid work of women. Indeed, the rise of capitalism, as we have seen, was tightly linked to the expulsion of women from Society, and their forcible relocation into the realm of Cheap – and cheapened – Natures (von Werlhof 1988; Mies 1986; Federici 2004; Moore 2015a).

A politics of nature premised on degradation rather than work renders the radical vision vulnerable to a powerful critique. This says, in effect, that pristine nature has never really existed; that we are living through another of many eras of environmental change that can be resolved through technological innovation (Lynas 2011; Shellenberger and Nordhaus 2011). Of course such arguments are rubbish. The counterargument – for the Capitalocene – understands the degradation of nature as a specific expression of capitalism's organization of work. 'Work' takes many forms in this conception; it is a multispecies and manifold geo-ecological process. This allows us to think of technology as rooted in the natures co-produced by capitalism. It allows us to see that capitalism has thrived by mobilizing the work of nature as a whole, and to mobilize human work in configurations of 'paid' and 'unpaid' work by capturing the work/energies of the biosphere.

Reimagining work in capitalism – beyond labor fundamentalism – provides a way forward in today's unpleasant reality. A revolutionary vision must be able to articulate a politics that links the crisis of the biosphere and the crisis of productive and reproductive work. A revolutionary politics of nature that cannot speak to the questions of precarious and dangerous work, of 'surplus humanity' (Davis 2006), of racialized, gendered and sexualized violence will be doomed to failure. A revolutionary labor politics unable to speak to the *ongoing* crisis of planetary life – and the *ongoing* impending 'state shift' in planetary systems – will be equally doomed. The time has come for a conversation about how to forge a radical vision that takes as its premise the organic whole of life and biosphere, production and reproduction.

Many of us are fond of putting forward some version of Einstein's point: 'We can't solve problems by using the same kind of thinking we used when we created them'. Most radicals – and I think most who align with the Popular Anthropocene – are keenly aware of this. How to ford the Cartesian Divide, in practical ways, is the great question. The bad news is that we find ourselves at multiple tipping points – including the destabilization of biospheric conditions that have sustained humanity since the dawn of the Holocene, some 12,000 years ago. The good news is that our ways of knowing – and acting – are also radically changing.

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